The TECH ENGINEERING NEWS

FEBRUARY, 1946

VOL. XXVII, NO. 6

TWENTY-FIVE CENTS

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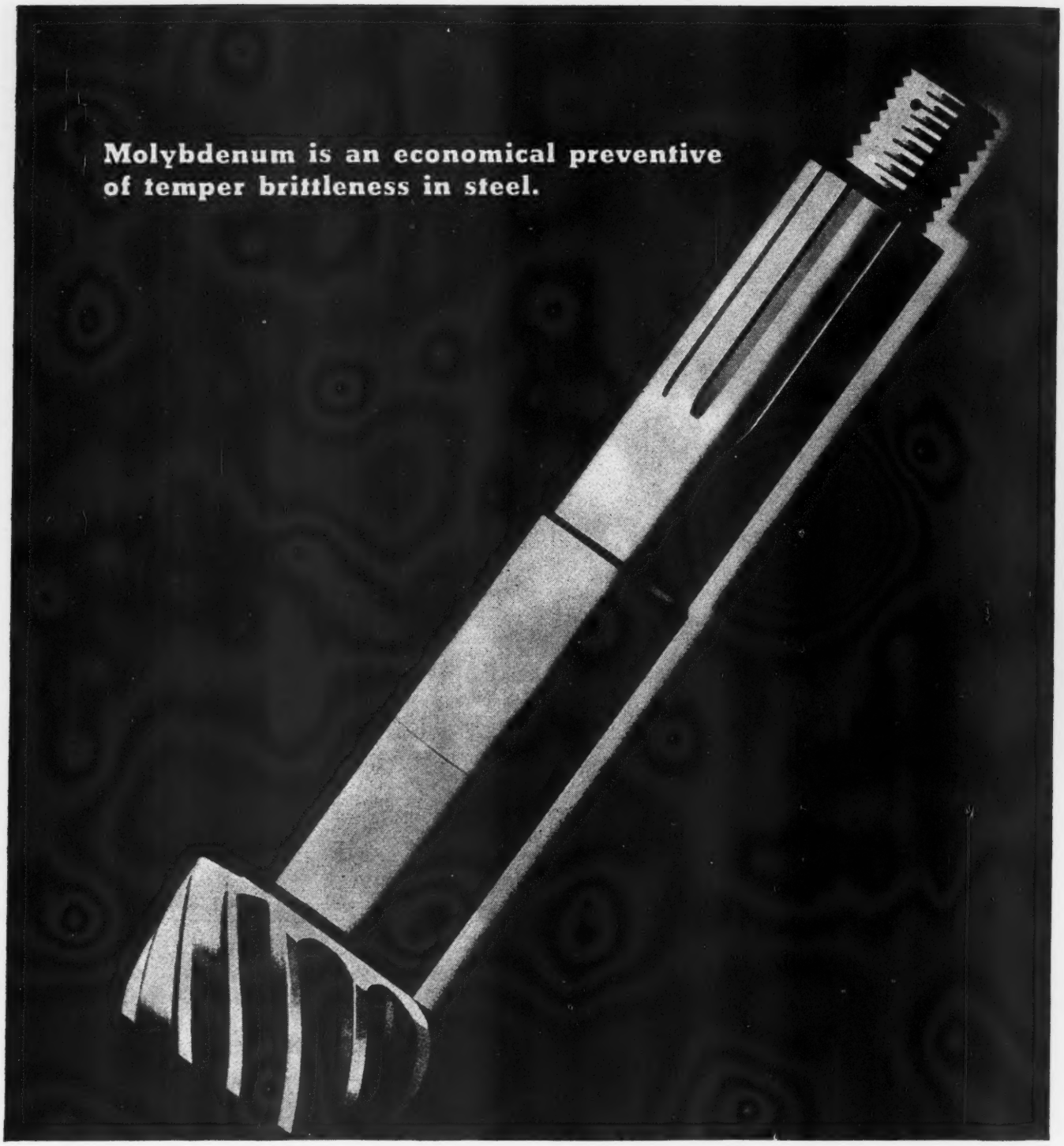

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MOLY

1846—GEORGE WESTINGHOUSE CENTENNIAL—1946

And suddenly—a wonderland of light...

It was an unforgettable sight that greeted the crowds at the Chicago Columbian Exposition, back in May, 1893.

For suddenly 250,000 incandescent lamps—more than there were in *all* the rest of *America* at that time—blazed in the night. They transformed the World's Fair Grounds into a gleaming wonderland of light.

George Westinghouse had done it again. Overcoming tremendous obstacles, he had accomplished the "impossible" . . . *in one short year.*

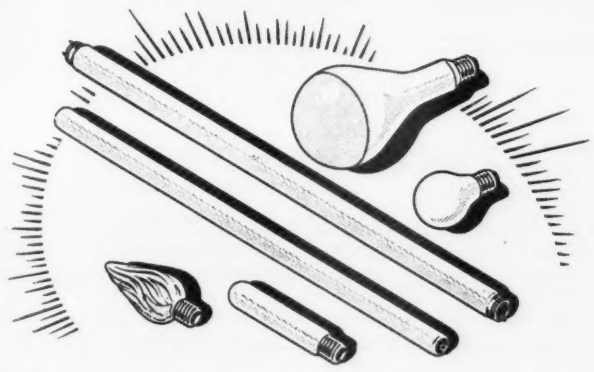
Using an entirely new principle, this great inventor-engineer had developed a completely *new type* of incandescent lamp—the famous "stopper lamp." And he had equipped a new glass factory to turn them out by the hundreds of thousands!

Here again, George Westinghouse in this historical light demonstration proved the vision and ability of a great engineer.

The lighting of the Columbian Exposition was a brilliant spectacle—and an important one, for it launched for all time the new age of electric lighting.

Westinghouse

PLANTS IN 25 CITIES OFFICES EVERYWHERE



TODAY *— the Westinghouse Electric Corporation, one of many companies founded by this great inventor, makes incandescent lamps in all sizes, from tiny "grain of wheat" surgical lamps to high-power flood lights . . . fluorescent lamps that glow without flicker . . . high-intensity mercury lamps for industrial use . . . Sterilamps* that kill air-borne bacteria. In all, over 10,000 different types of lamps are made, each the result of skilled engineering—and over half a century of diversified experience.*

*Registered Trademark

Tune in: JOHN CHARLES THOMAS—*Sunday, 2:30 pm, EST, NBC* • TED MALONE—*Monday through Friday, 11:45 am, EST, American Network*

Straight talk about your after-college job

No. 2. An engineer thrives on achievement

A GREAT MANY of us here at The Timken Roller Bearing Company are engineers. So when we say an engineer thrives on achievement we speak from our own experience.

For instance, suppose you had helped develop Timken *Super-Steel*—that magnificent new alloy which made possible the jet propulsion engine for American fighting planes.

As you know, most baffling problem in jet propulsion was one in metallurgy. For years, engineers had been stalled for lack of a metal to use in the turbine wheel —heart of the jet engine.

Every metal tried had ruptured, distintegrated or lost its form.

Yet engineers of the Timken Company, by relentless night and day research, solved the problem in a matter of months.

■ If you were an engineer at the Timken Company, you would be proud of your part in that job. You would feel confident of licking the next tough problem. And you would be a better engineer for it.

We could give you a long list of equally impressive achievements.

But the point is that our engineers *get the chance* to do important and exciting work. They get the chance because our company designs and produces bearings for every industry in America, and because, as a specialist in high grade alloy steels, we are confronted continually with problems, which have baffled the best engineering brains in the country.

■ Such an environment spurs the development of latent engineering abilities.

Under our "Work-as-You-Learn" Plan a young engineer works in various departments of our business, selected to bring out special aptitudes. Then he is assigned to the line of work for which he is best suited. This helps avoid false starts in the critical first years of a career and helps assure more rapid advancement later.

We are particularly interested in men who are studying Metallurgical, Mechanical, Chemical, Mining or Electrical Engineering. If you would like to know more about opportunities with our company, write to us now. Address The Timken Roller Bearing Company, Canton 6, Ohio.

The Timken "Work-as-You-Learn" Plan of Training

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2. Tapered Roller Bearing Design
3. Industrial Application Engineering
4. Automotive Application Engineering
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7. Tool Steel Mill and Forge Shop
8. Production Scheduling Department
9. Metallurgical Laboratory
10. Metallurgical Service (Customer Contacts)

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PRODUCTS: World's largest manufacturer of *tapered roller bearings*. Specialists and large producers of *fine alloy steels* for industry. Manufacturers of *removable rock bits*. **U.S. PLANTS:** (All in Ohio) Canton, Columbus, Mount Vernon, Wooster and Newton Falls. **FOREIGN ASSOCIATE PLANTS:** British Timken, Ltd., Birmingham, Wolverhampton, Northampton, England; S. A. Francaise Timken, Asnieres (Seine) France. **SALES OFFICES:** In principal cities.

Du Pont *Digest*

Items of Interest to Students of Chemistry, Engineering, Physics, and Biology

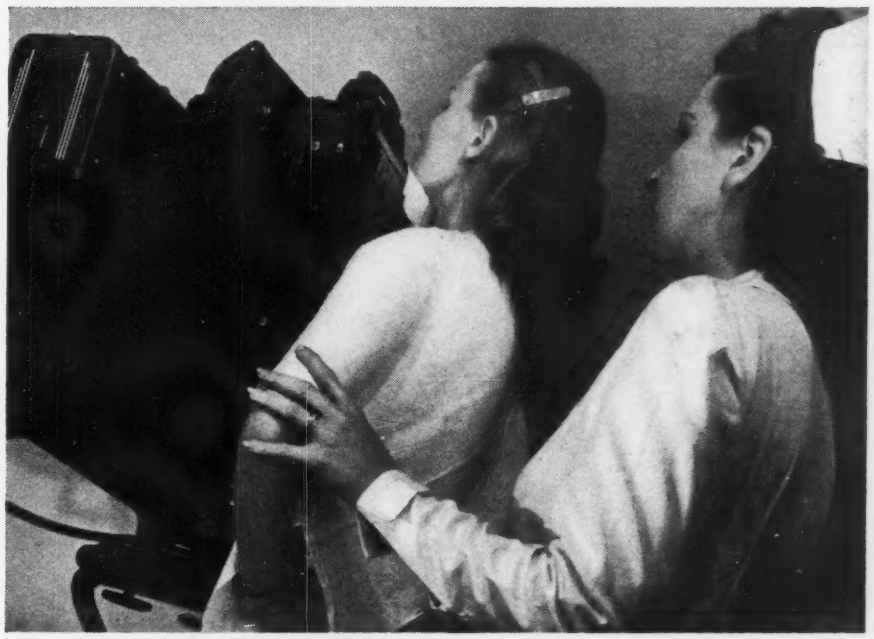
Good News for Unsuspecting T. B. Victims

HERE is news that marks another step ahead in the fight against t. b.—news about free tests and new x-ray equipment.

As a means of locating possibly one and a half million undetected cases of tuberculosis, the U. S. Public Health Service plans to offer chest x-ray tests to nearly every American during the next five years. This survey is made possible through the use of new equipment which produces chest x-rays on small film, thus permitting mass examinations at reduced cost.

The development of the new film and the special fluoroscopic screen was not accomplished overnight. Organic chemists, physical chemists, physicists, and other technically trained men were required to make exhaustive studies before the problem was solved. Special sensitizers had to be found. Phosphors and activators had to be formulated for the screen. Both screen and film had to be of ultra-fine grain, and the spectral emission of the screen had to be adjusted to the spectral sensitivity of the film.

Men of Du Pont are proud of their part in the development of this new aid to medical science. The fact that their efforts helped to contribute a new benefit to society is a heart-warming inspiration



Miniature X-Ray Pictures May Uncover 1,500,000 Hidden Cases

• • •

Chemical Pest Control for more and better food

"Eating"—somebody has remarked—"is a habit." It certainly is! Men, women and children all have a firm, fixed habit of eating . . . so enough food must be grown for them to eat.

Du Pont chemists, plant pathologists, entomologists and engineers have helped the farmer to increase the nation's food supply through their never-ending search for better ways of protecting crops. The development of new fungicides is a typical example.

Du Pont men were faced with the problem of finding chemicals to be used in treating fungus diseases of plants, under conditions in which the use of copper and sulfur proved harmful. After long and intensive research they found the answer in the salts and organic derivatives of dithiocarbamic acid—such as the iron and zinc salts of dimethyldithiocarbamic acid, and tetramethylthiuramdisulfide.

Agriculturists now know Du Pont's iron salt of dimethyldithiocarbamic acid as "Fermate," and the zinc salt of the same acid as "Zerlate." These fungicides are products of Du Pont research—research that is helping the farmer to bigger crops of better quality.

• • •

Now—Faster Dry Cleaning

Two Du Pont products—"Perclene" perchlorethylene and "Triclene" trichlorethylene—have made dry cleaning quick and safe. These fluids clean clothes speedily, so that delicate garments need remain in the machine only a few minutes. They leave no telltale cleaning odor.

More facts about Du Pont—**Listen to "Cavalcade of America," Mondays, 8 P.M. EST, on NBC**

Questions College Men Ask about working with Du Pont

"WILL I GET LOST IN A BIG COMPANY?"

At Du Pont, every effort is made to see that individual ability is recognized and rewarded. New chemists and engineers work in small groups under experienced supervisors. As aptitude is shown, they are given more responsibility. While offering the broad avenues of promotion that go with size, Du Pont's group system assures college men of the sympathetic, friendly conditions of employment commonly associated with smaller organizations.

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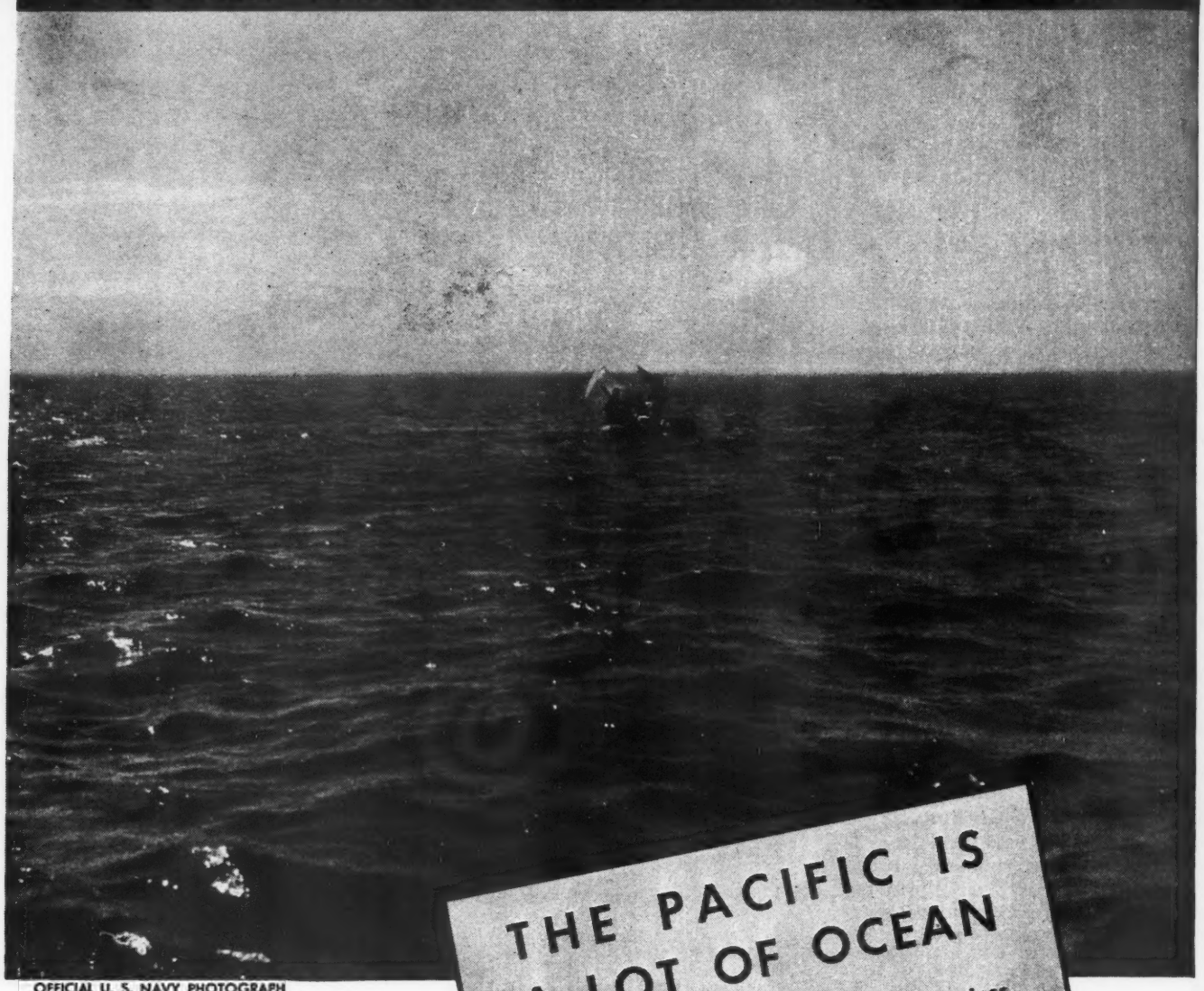

OFFICIAL U. S. NAVY PHOTOGRAPH

THE PACIFIC IS A LOT OF OCEAN

It is a big place to get lost in. The ceaseless search by Navy PBM "Mariners" has saved the lives of many downed fliers. Sometimes the plane can make the rescue; often radio sends help on its way.

The Navy knows how important radio equipment is. 3 out of 4 of the Navy's ships — landing craft and larger — use receivers designed by National.

HRO

NC-200

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NATIONAL RECEIVERS ARE IN SERVICE THROUGHOUT THE WORLD

The TECH ENGINEERING NEWS

PROFESSIONAL JOURNAL OF THE UNDERGRADUATES

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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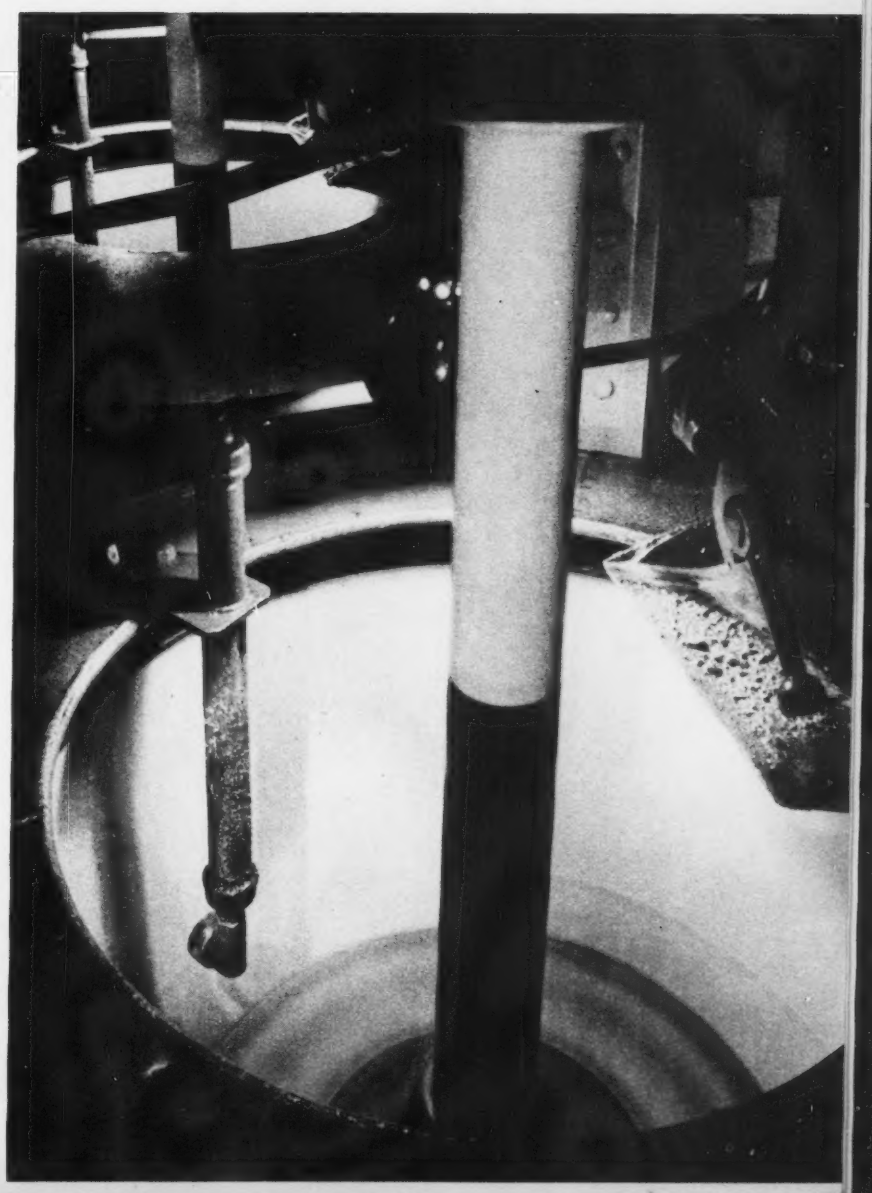

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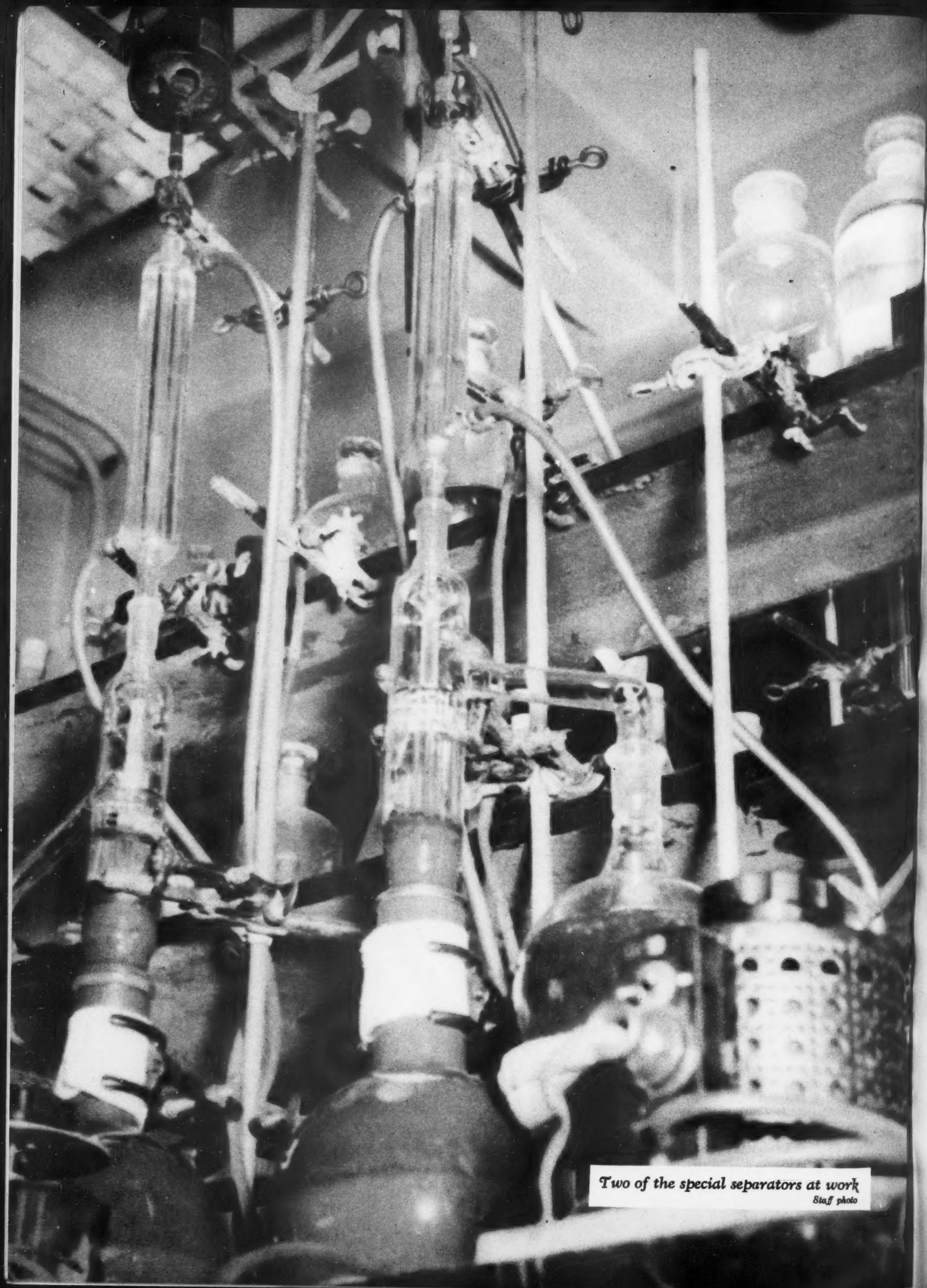


Two of the special separators at work
Staff photo

The Sugar Research Foundation at M. I. T.

By ALLEN SCATTERGOOD
Research Associate

IT has been said that the oldest and best established industries are the last to adopt research programs. In 1944, over one hundred years after modern sugar refining started, the Sugar Research Foundation was organized to carry out fundamental biological, nutritional and chemical research on sugar.

Most other industries which manufacture chemicals had been doing fundamental research for years, but the sugar industry considered their product as a food and not as a chemical and did not see the need for research until recently. Those who feel that the Sugar Research Foundation was created at an inopportune time, during a grave sugar shortage, must realize that the possible world production of sugar is greater than that produced at present, and that part of the recent scarcity of sugar is due to lack of visionary planning by both the industry and the government.

The Sugar Research Foundation sponsors many projects devoted to the biological behavior of sucrose in various institutions throughout the country. However, its main project devoted to the chemical study of sugars is at M. I. T. This project has been granted an appropriation of $125,000 for a five-year period. The research is not limited to the study of sucrose alone, but may be applied to any division of sugar chemistry.

Sugar (sucrose, $C_{12}H_{22}0_{11}$) is produced in larger quantities than any other pure organic substance. In spite of the tremendous production, very few pure chemical substances are produced from sucrose on the industrial scale. This is in marked contrast to the large chemical production from alcohol, calcium carbide, petroleum, and other raw chemical materials. The dearth of chemicals from sucrose is due to two reasons:

1. The instability of the sucrose molecule makes it difficult to produce chemicals and derivatives from it.

2. There has not been sufficient research to overcome these difficulties.

There are several incentives for doing research designed to produce chemicals from sugar on the industrial scale. Among these are the low cost of sugar in spite of its high purity, its reactivity and its availability.

The chemicals which may be obtained from sucrose are divided into two classes:

1. Derivatives of the unchanged sucrose molecule. The names of such derivatives always include the word "sucrose" in them.

2. Chemicals derived from the fragments of the sucrose molecule. Since the sucrose molecule is relatively large as molecules go, the fragments may be quite varied and extensive.

Very few crystalline derivatives of sugar are known. Sucrose octaacetate is the only one manufactured on the industrial scale. Oddly enough, the sugar industry does not produce this substance; it is made by the manufacturers of acetic anhydride. It is used as a plasticizer, in adhesives, and for the treatment of paper. At M. I. T. the Sugar Research Foundation has done many experiments in order to obtain other crystalline derivatives of sucrose, but so far these experiments have met with little success.

Among the chemicals which can be obtained from the fragments of the sugar molecule, the most interesting from the commercial point of view seems to be fructose (levulose). In 1847, it was shown that invert sugar, which results when sucrose is boiled with dilute acid solutions, is a mixture of glucose (dextrose) and fructose. The separation of glucose and fructose in good yields and in the crystalline condition from invert sugar is a problem which has never been satisfactorily solved.

The commercial production of fructose would be very desirable. It is several times sweeter than ordinary sugar, so that less can be used to get the same sweetening effect. Thus people who have a tendency toward overweight would benefit by its use without depriving themselves of the nutritional function of sugar. Fructose is more soluble and dissolves faster than sugar. It could therefore be used to advantage in sweetening cold drinks such as iced tea in which ordinary sugar dissolves with difficulty. It could be used in place of sucrose in formulating soft drinks as it is more stable than sucrose in acid solution and the taste of the drink would therefore not change with time. It could be used for thickening and extending maple syrup, honey, and other products from which sucrose has a tendency to crystallize. Finally, fructose is said to be tolerated better than sucrose and glucose by diabetic persons.

Fructose occurs as such in certain plants such as the Jerusalem Artichoke, but because it is not soluble its extraction is difficult, and production from this plant would mean that valuable land in the temperate zone would have to be turned over to its cultivation.

Dr. Scattergood and one of the laboratory agitating machines
Staff photo

Three methods of getting fructose from sucrose have been suggested. They are as follows:

1. Separation of invert sugar into fructose and glucose.
2. Solvolysis of sucrose followed by a separation.
3. Electrolytic oxidation of glucose in invert sugar.

The Sugar Research Foundation at M. I. T. has made preliminary experiments on all three of these methods. The first separation of invert sugar into glucose and fructose was accomplished many years ago by the use of lime which forms a solid compound with fructose. However, alkalies isomerize sugars into a variety of ill-defined and non-separable substances, so the yields are low; hence this method has not been seriously considered here.

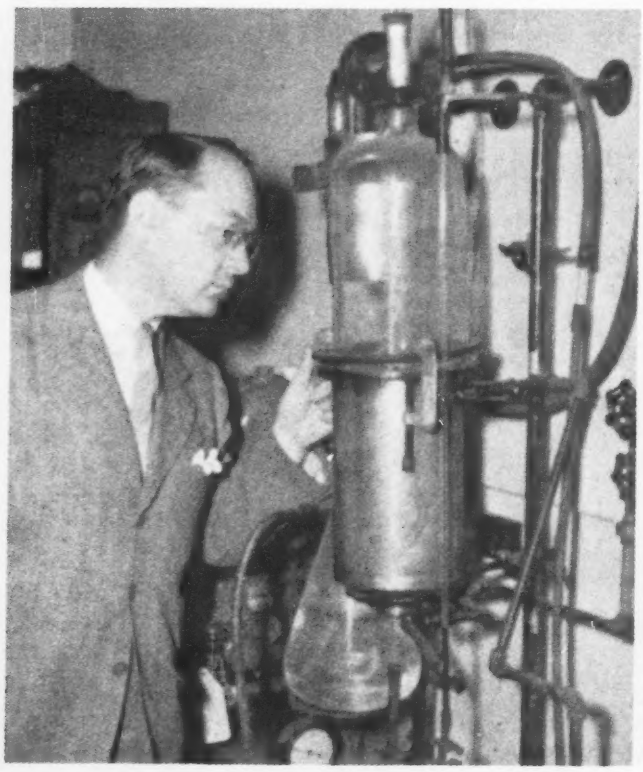
A section of one of the lab desks *Staff photo*

The first process to receive preliminary investigation was the extraction of fructose from an aqueous solution of invert sugar by means of a water-immiscible solvent. Fructose and glucose have somewhat different solubilities in solvents and if an invert sugar solution is shaken with a suitable solvent, one of the components might have a tendency to accumulate in the solvent layer.

A phase diagram of the system fructose-water-solvent was made for one of the solvents which seemed most appropriate. The results indicated that an enormous amount of research would have to be done before the solvent separation is satisfactorily worked out. There are about fifty solvents for which phase diagrams are needed at several temperatures. Once the most suitable solvent is discovered it would be necessary to construct a battery of extractors and the difficulties of such a separation might well turn out to be as great as the separation of U^{235} from uranium. The Sugar Research Foundation does not have the resources to carry out such a large program of research as long as its funds are not concentrated in chemical research alone.

The Sugar Research Foundation at M. I. T. developed a laboratory motor-driven apparatus employing a solvent less dense than and immiscible with the aqueous solution which it continuously extracts. This was used in the extraction of fructose and other sugar derivatives from aqueous solution despite the unfavorable distribution of the sugar between the water and the solvent.

Dr. Robert C. Hockett of M.I.T., national scientific director of the Sugar Research Foundation



The second method for the production of fructose which has received preliminary study is the solvolysis of sucrose. The general reaction of sucrose with a solvent in the presence of a catalyst is assumed to be as follows:

Sucrose+solvent→glucose+a solvent derivative of fructose. The mixture of glucose and the solvent derivative of fructose should be more easily separated than a mixture of glucose and fructose. Such a reaction had been previously studied only for the solvent, methanol. At M. I. T., alcohol (ethanol) was selected as the solvent. (People have been mixing sugar and alcohol together for years and then drinking the mixture—it is called an "Old-Fashioned"; but no one had ever thought of studying the reaction between sugar and alcohol before.) Nearly one hundred experiments were done in which the variables of sucrose concentration, acid concentration, temperature, time, fineness of solid sucrose, and presence of impurities were changed before the optimum conditions for the alcoholysis of sucrose were discovered. The reaction:

Sucrose+ethanol→glucose+ethyl fructosides

was found to be over 95 per cent complete under these optimum conditions. The difference between the solubility of glucose and ethyl fructosides is so great that considerable progress has been made in their separation. The ethyl fructoside which has been separated from the glucose is then hydrolyzed to fructose and alcohol. Although additional research on this method is neces-

sary, it appears quite likely that it will result in a successful means of obtaining fructose — or at least a cocktail with a novel flavor.

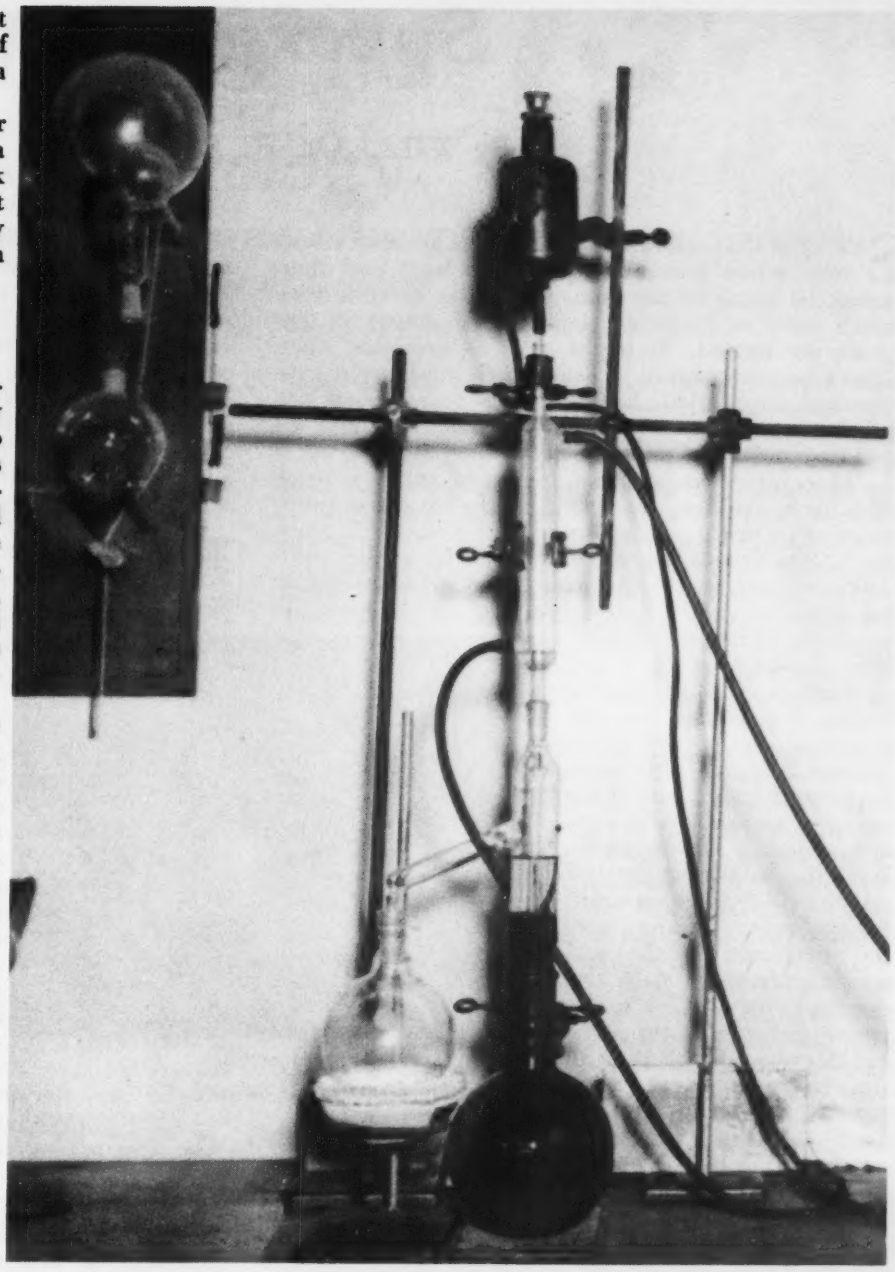
The third method tried for fructose production was based on a badly worked out patent of Fink and Summers in which an invert sugar solution was electrolytically oxidized in the presence of calcium carbonate. The reaction is:

Invert sugar + oxygen + calcium carbonate → calcium gluconate + fructose + carbon dioxide

Under the conditions of the reaction, the fructose is only slightly oxidized, while the glucose, due to its different chemical structure, is completely oxidized to calcium gluconate, which crystallizes out and can be removed by filtration. Some crystalline fructose has been secured at M. I. T. by this method, but the reaction is complicated by side-reactions and by-products which tend to prevent the crystallization of the fructose.

The most successful method for the preparation of fructose from sucrose will probably be a combination of one or more of the three methods already studied. Although the problem of a commercial process of preparing fructose from sucrose is far from being solved, it will be seen that considerable progress has been made towards this end here.

The residue of the sugar cane plant is a fibrous material called bagasse (see center spread). It consists largely of cellulose and xylans which are both insoluble polymerized sugars. The xylan may be hydrolyzed to a sugar with five carbon atoms in the molecule called xylose, but it is difficult to secure this sugar in the crystalline condition from the impure hydrolysate. A new method for the preparation of crystalline strontium xylonate directly from agricultural waste materials such as bagasse, cottonseed hulls and corn cobs has recently been developed at M. I. T. This involves hydrolyzing the agricultural material under analytically controlled conditions, and electrolytically oxidizing the resulting hydrolysate. Another crystalline substance whose production directly from agricultural waste material has been developed at M. I. T. is gulonolactone. Lactones have a delayed acidifying action and may prove valuable in industry.



Staff photo

A motor-driven separator, specially designed for use in sugar research

The use of sugar in plastics has also received some attention at M. I. T. Plastics are often formed by heating organic substances to over 200° C. Under such drastic conditions, sugar is decomposed and forms brown-colored materials, volatile products, and carbon. When an attempt is made to incorporate sugar into reaction mixtures used to make plastics, the high temperature decomposes the sugar as it reacts. Other plastics are formed by allowing monomers to polymerize under relatively mild conditions. Such monomers are often unsaturated. However, sugar is not unsaturated, and there is no known way to cause it to polymerize.

The problem of using sugar in plastics may be solved by one of three general considerations:

1. Modify the sugar molecule in such a way that it will polymerize under mild conditions. This includes introducing unsaturation so that the sugar derivative will polymerize at temperatures which will not destroy it. Unsaturation could be introduced by reacting the sugar with some substance that is unsaturated or by inducing unsaturation within the sugar molecule itself. The latter procedure is more attractive but far more difficult.

2. Convert the sugar into derivatives better able to withstand the high temperature necessary for certain kinds of plastic formation. This problem of blocking some of the groups in the sugar molecule, but leaving enough to react to form the plastic is also very difficult.

3. Develop ways to manufacture the chemicals commonly used in plastics production from sugar. The possibilities of producing from sucrose chemicals which

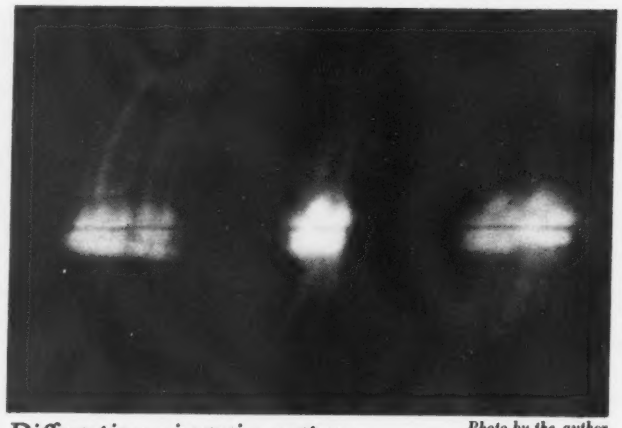
(*Continued on page 222*)

Supersonics

By WILLIAM H. PEAKE, 2-46

SUPERSONIC vibrations is the name given to vibrations which have a frequency so high that they cannot be heard by the human ear; that is, vibrations which have a frequency higher than about 20,000 cycles per second. It might seem at first that since these vibrations cannot be heard, they would have little practical application, but science has developed not only means for detecting their presence but also an amazing variety of practical uses.

There are two principal means of exciting these vibrations, the first depending on the magnetic properties of matter, and the second on its electrical properties. The former, the so-called magnetostriction oscillator, depends on the fact that when a ferromagnetic rod is placed in a magnetic field parallel to itself, its length is changed slightly. This change may be either an increase or a decrease in length, depending on the nature of the material, the temperature, the previous magnetic history, and various other factors, but by rapidly changing the magnetic field, the length of the rod may be made to change correspondingly. By using special electronic circuits and carefully designed rods, frequencies up to 300,000 cycles per second can be produced by this method. But since the change in length of the rod is only about one millionth the length of the rod itself, the vibrations are not very intense. The second method of producing high-frequency oscillations is the piezoelectric method. This method is the one most frequently used at the present time for generating supersonics, and it is by far the most effective for producing both high frequencies and large power output. It depends on the fact that when an electric field is applied between certain faces of a quartz crystal, the crystal either contracts or expands in the direction of the field. If the crystal is subjected to a rapidly varying field, supersonic vibrations are set up with the same period as that of the field, and with an amplitude which depends on how close the frequency of the electric field is to the resonant frequency of the crystal. Since the resonance is very sharp, these crystals also find a wide application in radio transmitters as frequency stabilizers, but here we shall only discuss their use as sound generators. Quartz crystals can be excited to frequencies of 50,000,000 cycles per second in the fundamental, and the odd overtones also appear, which enables the exceedingly high frequencies, which are sometimes needed, to be obtained.



Diffraction rings in water caused by supersonic waves

Photo by the author

An interesting application of these supersonic waves in liquids is for measuring the velocity of sound in the liquid. Normally such a determination would require a great deal of liquid, and even then it would not give very accurate results. However, if we set up supersonic vibrations in liquid, the waves will cause periodic changes in the density, and thus of the refractive index. Consequently the liquid will act as a diffraction grating for parallel light sent through it. Since the frequency can be determined by electrical means, and the wavelength is known from the amount of diffraction, the velocity of sound in the liquid may be determined with great accuracy. The importance of knowing the velocity of sound in liquids is that it enables the specific heat at constant volume, which can otherwise be computed only from very complicated thermodynamic relations, to be found if the isothermal compressibility is known.

When supersonic vibrations are set up in solids, the diffraction patterns enable us to determine the elastic constants of the material, which cannot always be done by other means.

The interference method has given a result that is more accurate for only three measurements than the static method gives as an average of several thousand measurements.

Supersonics may also be used to create a stroboscopic light beam, since the intensity of light diffracted from a supersonic grating is intermittent, because the grating itself is created and destroyed at twice the frequency of the supersonic waves. This is especially useful for stroboscopes of high frequency, but unfortunately they can only be used at the definite natural frequencies of the crystals, and therefore a continuous change of frequency is not possible.

Another use for the modulation of supersonic waves in liquids is in the Scophony system of television, which, although it requires a mechanical scanner, gives a higher screen illumination than the ordinary mechanical systems.

One of the first technical applications of supersonics was for detecting obstacles such as icebergs, and for taking depth sounds from ships at sea. Here a short train of supersonic waves is sent out by a piezoelectric oscillator in the hull of a ship, and the time required for the train to strike the obstacle, such as a submarine, iceberg or the bottom of the ocean, and then return to the ship, is measured. Since the velocity of the sound is known, the distance to the object may be easily found. This is the same principle as radar, and if the echo-sounding device is connected to a plotting instrument, a direct profile of the ocean bottom may be obtained. It is even possible to deduce the nature of the sea bottom from multiple echoes, and one can also observe the presence of schools of fish.

Supersonic vibrations may also be used to prepare stable emulsions of such immiscible liquids as water and oil, mercury, lead and various oils and paraffins. The two liquids are put in a test tube which is dipped in an oil bath acted on by powerful supersonics. The liquids

(*Continued on page 222*)

THIS IS M·I·T·

Geology

By WARREN J. MEAD
Professor of Geology

Drawings by Professor Frederick K. Morris

WHY Geology? What do geologists do? Geology's part in "Victory in Science" and in a peacetime world should answer these questions. The role of Geology is neither glamorous nor romantic, but it is as essential as eggs in an omelet.

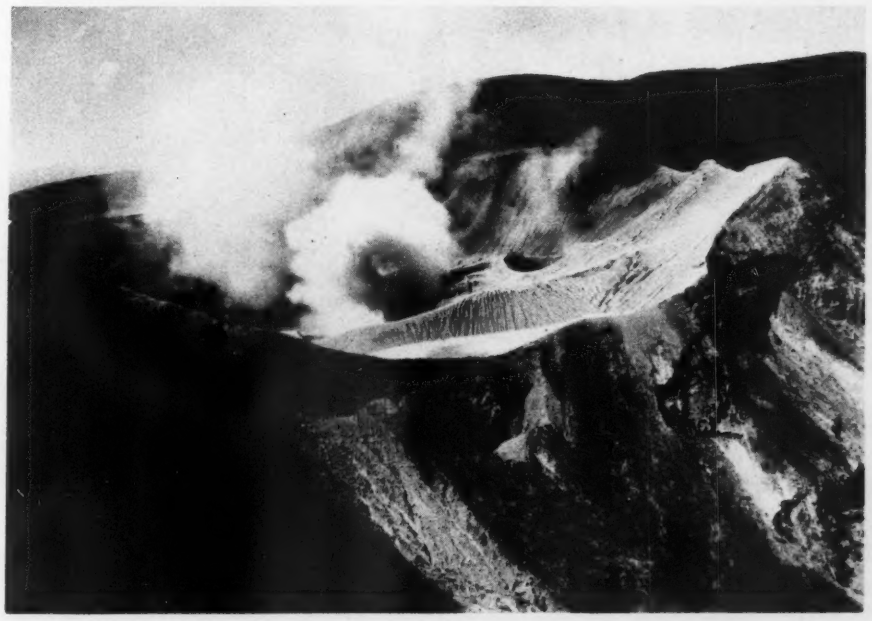
The explosion of the atomic bomb is still reverberating in Science, in Congress, in the press, and in international affairs. It might well be called the greatest achievement of coördinated science. This type of atomic bomb (there may be other kinds later) requires the heavy element uranium and in unprecedented quantities. This strategic element can only be obtained from ores and rocks containing uranium minerals. Geologists had to find the uranium. They will be searching for more of it for some time, as atomic energy most certainly will have peacetime uses. Uranium is the egg in the atomic energy omelet.

Second, perhaps, to the atomic bomb in combative importance is the proximity fuse — that amazingly condensed transmitting and receiving radio station mounted in a projectile, bomb, or rocket, which is able to advise itself of the proximity of a target and detonate the charge at the right time. Vital parts in the radio equipment of this ingenious gadget are tiny precisely ground plates of quartz crystal. In every radar installation, similar quartz plates are as essential to its operation as is your heart to your life. Each radio transmitting and receiving set requires these vital quartz plates. Quartz is a mineral; it is found in the earth; its discovery and production is the geologist's responsibility. Geologists from this department and from many other sources rendered their services in a search in Brazil and other foreign countries, and in this country, for the crystals of quartz pure and perfect enough to provide the millions of tiny plates required for the job. But the responsibilities of geologic science did not end with the discovery of the crystals. Methods had to be developed for mass production of these quartz plates, ground to a critical thickness measured in terms of light waves, and cut at exactly the correct angle to the axes of the crystals. This job of tailoring the crystals fell largely to the mineralogists, particularly those trained in X-ray crystallography, and many of the men in this important phase of the work were trained in the Department of Geology at M. I. T.

At one stage in the development of military appliances, an ingenious gunsight created an unusual demand for calcite crystals, and this urgent requirement sent geologists on a search for the calcite. Likewise fluorite, also a crystalline mineral, was demanded and again the geologists had to produce. There were at least a score of unusual but vitally important minerals and metals urgently required in unprecedented amounts; geology had to do the job and did it.

Every bomb, projectile, rocket, and the guns and rocket-launching devices are made of metal. Tanks and all other automotive units, naval vessels, landing craft, ships, and tens of thousands of mines to sink the ships were metal. Most of the bombers, fighters, and transport planes were largely built of aluminum and called for unprecedented tonnage of that metal. Iron, steel, aluminum, magnesium, copper, zinc, lead, tungsten, molybdenum, and many other metals were needed in staggering quantities. And the planes, tanks, mobile guns, jeeps, and automotive equipment of all kinds, our fighting ships and submarines and essentially all marine transports were moved by gasoline and fuel oil. Expanded wartime industry used all available hydroelectric power and in addition to this, prodigious amounts of coal and oil. Clearly the war could not have been fought and won without metals, minerals, and fuels, and these had to be taken from the ground. Known sources were inadequate. Normally available foreign sources were in many instances cut off. New sources had to be found. Geologists had the heavy responsibility of combing our own land and accessible foreign countries for new sources of these vitally strategic materials. The United States Geological Survey and the Federal Bureau of Mines employed great

Irazu volcano, Costa Rica — *Technology Review*



numbers of geologists in this effort and the job was done. All divisions of the War Production Board dealing with metals and fuels required geological advisers on their staff in Washington and in the field.

Geophysicists were drafted from their work in mineral industry to engage in research and development of means of detecting submarines. This research developed a magnetic device carried in an airplane and capable of locating submerged submarines. This device is of interest to geologists because it provides a method for making magnetic surveys from airplanes, and in fact is already being used for that purpose.

Geologists studied and interpreted the terrain for landing field locations and for purposes of military strategy and could have rendered far greater services of this type. The treatment and foundation design of landing fields, and foundations of heavy military installations called for engineering geology. Water supply for the armies both in this country and in foreign lands relied on geological service. Prior to the European invasion, English geologists were smuggled onto the Normandy beach to examine samples of sand and soil so that invasion could be properly prepared and would not be surprised by unanticipated conditions.

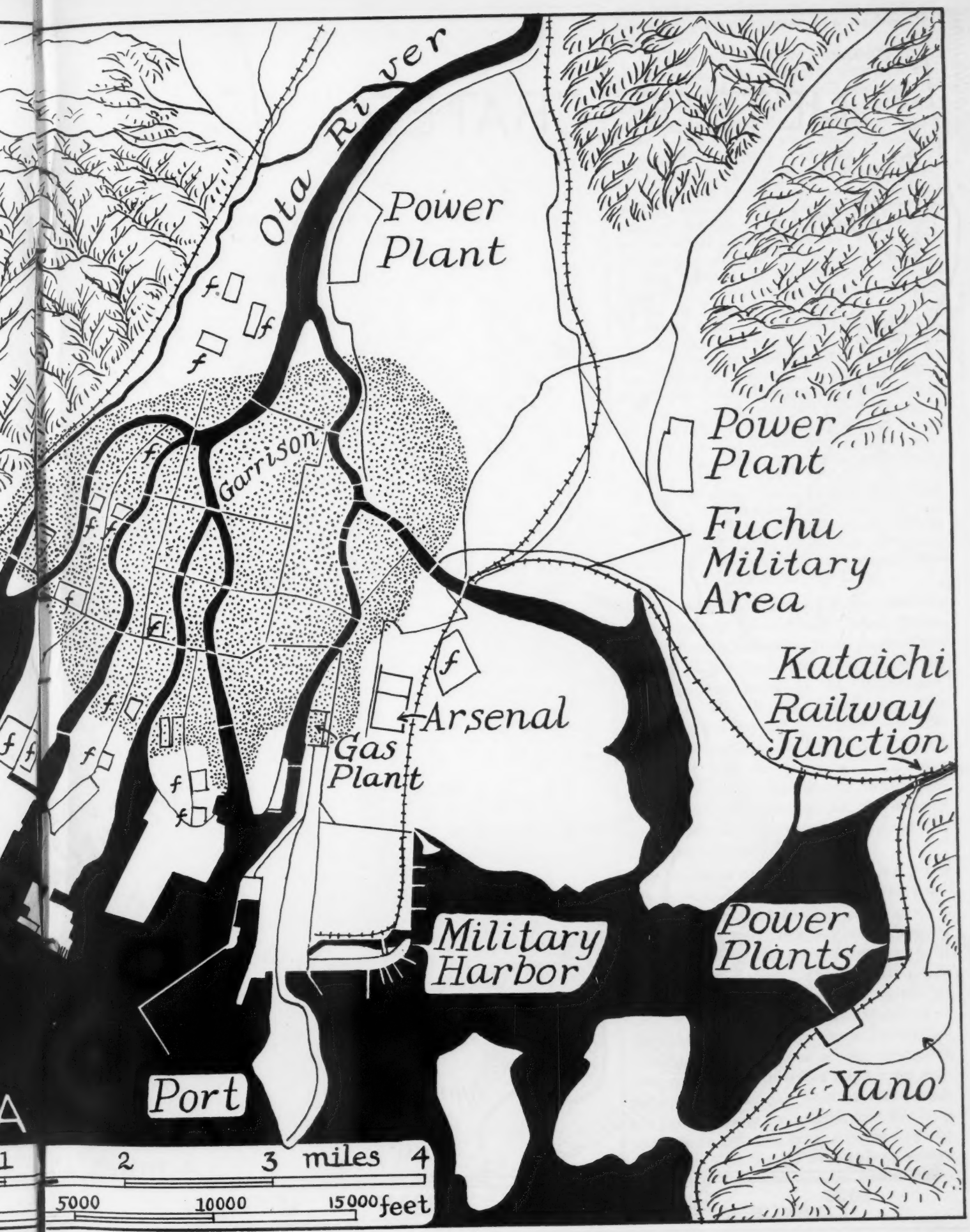
The peacetime services of geology embrace not only service to industry but penetrate importantly into the problems of international affairs. Military and political power are clearly dependent on industrial power which in turn is in a large measure determined by sources and availability of metals, fuels, and other mineral products. These unfortunately are unevenly distributed about the earth, and no country is completely independent of outside sources. The objective of war may be largely boiled down to control of raw materials and it follows that geological knowledge of the distribution and nature of internationally important mineral resources is of critical importance to the statesman handling international problems.

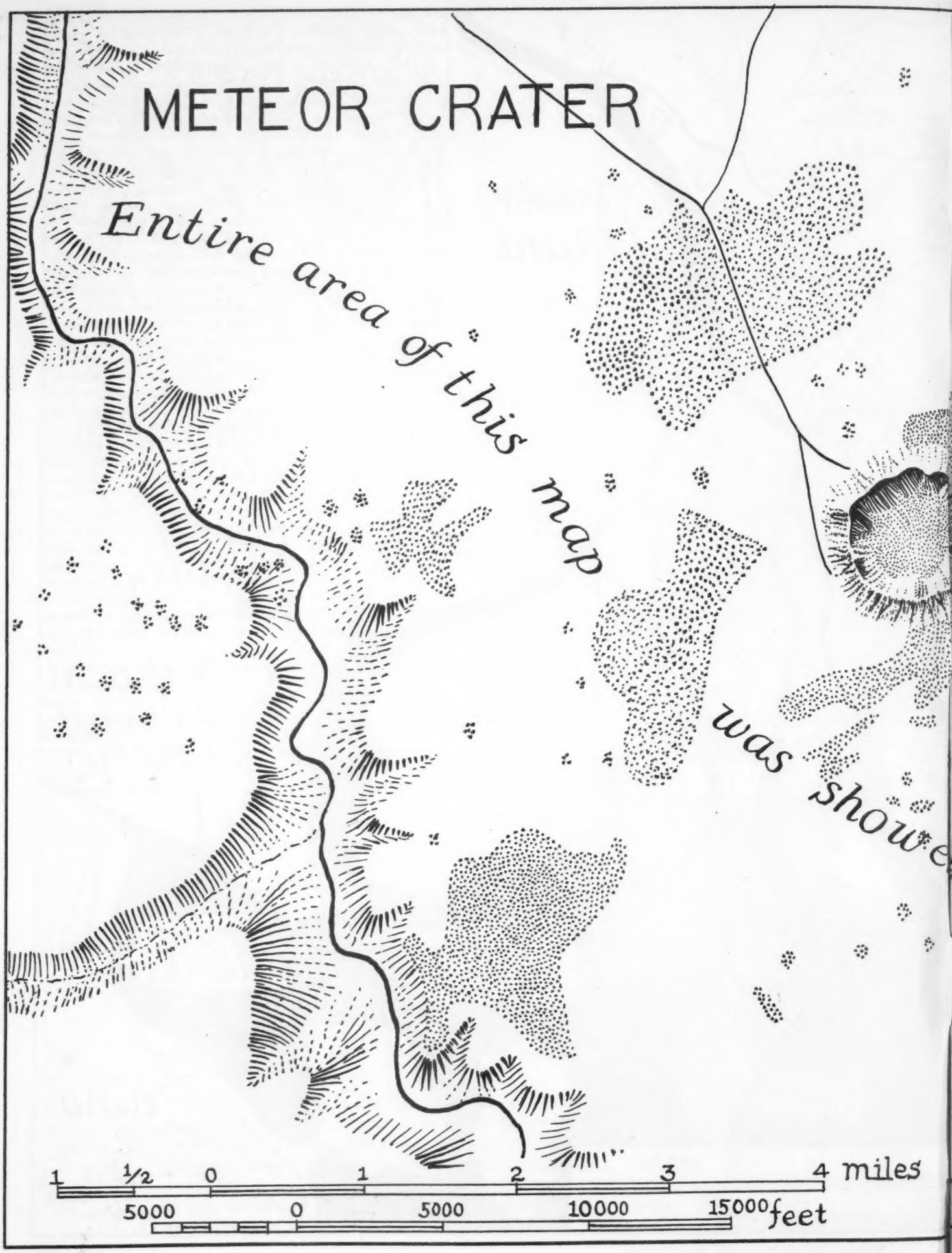
The man or woman attracted to the study of geology may be assured that it presents opportunities for profitable usefulness. He may look forward to an interesting career in the development of mineral resources for mineral industry, in state or federal geological surveys or mining bureaus, as an engineering geologist in the service of national, state, or private enterprises, concerned with large-scale engineering structures or

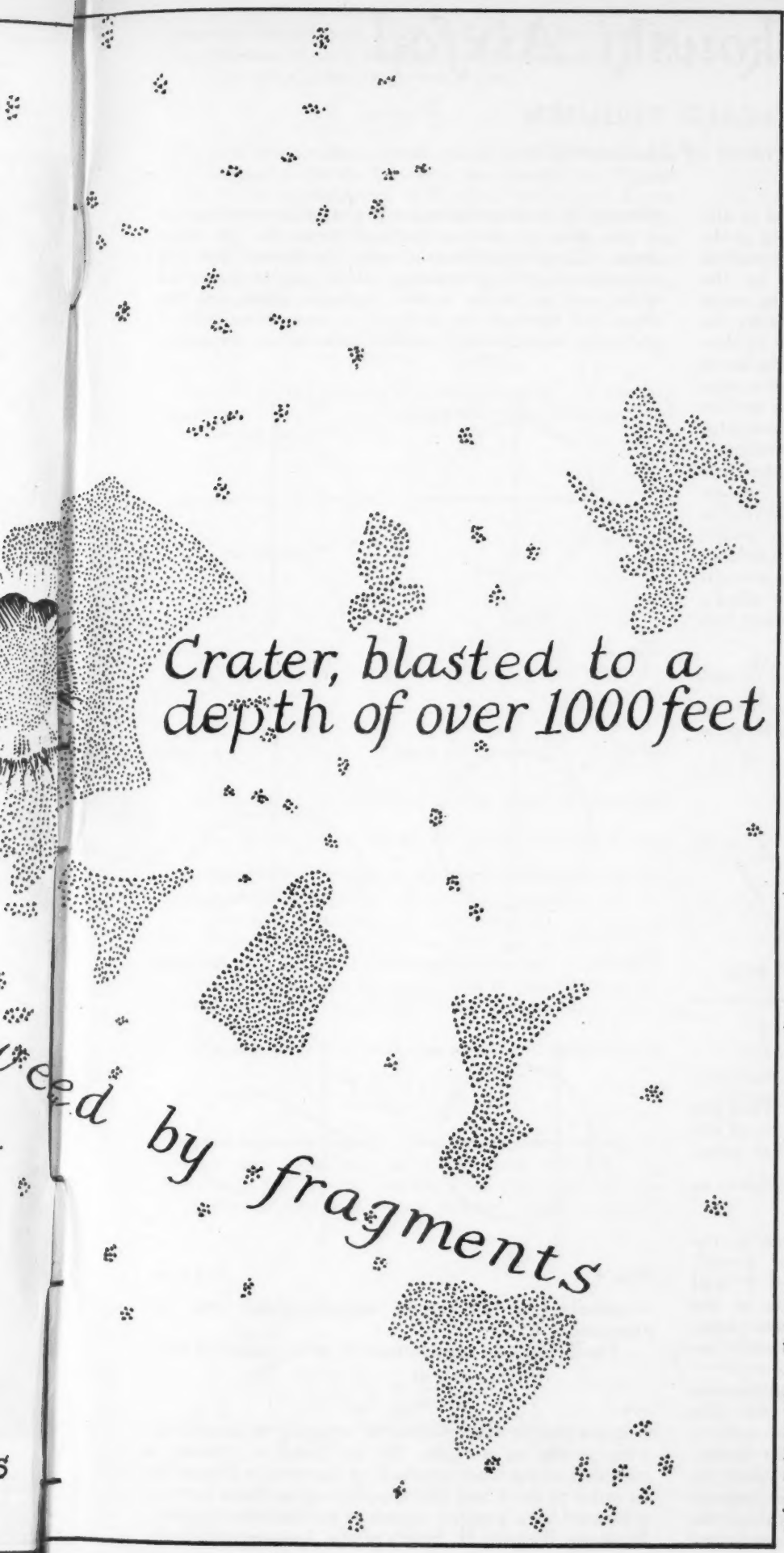
A geological feature made by an astronomical bomb, compared with man's best effort at destruction: Meteor Crater in Arizona — Hiroshima.

Sketch map of Hiroshima, compiled from Japanese maps and public reports. Built upon the delta of the River Ota, the city is a cross between a Venice and a Canton. The natural distributary rivers of the delta have been rebuilt as canals, arteries of cheap transit; while bridges and roads carry the faster traffic between the island-boroughs; and railroads and highways drape the landward wings of the triangular delta, connecting the city and port with the hinterland.

The letter "f" stands for "factory." The devastated area, shown by stipple, is at best an approximation and is almost certainly too large. In comparing this map with that of the Meteor Crater, note that the atomic bomb was consciously directed at very delicate structures — buildings and bridges — and that all damage was confined to the surface.


Ota River
Power Plant
Garrison
Power Plant
Fuchu Military Area
Kataichi Railway Junction
Arsenal
Gas Plant
Military Harbor
Power Plants
Port
Yano
2
3 miles
4
5000
10000
15000 feet


METEOR CRATER
Entire area of this map
was showed a
1 1/2 0 1 2 3 4 miles
5000 0 5000 10000 15000 feet



with highway problems, or he may choose to follow an academic career as a teacher and researcher.

Geology is perhaps the most widely travelled science. The geologist's problems are worldwide, and since they will not come to him, he must travel to them. Geology is for the most part out of doors, and the geologist must do much of his work close to nature, often under primitive conditions.

The curricula in geology at M. I. T. have in common a sound foundation of mathematics, physics, and chemistry, because physical geology at M. I. T. can be defined as the application of physical sciences to geological problems. Professional training in geology cannot be satisfactorily accomplished in the four undergraduate years and should be followed by a year or more of graduate study. Geological employment may be had after the four-year course, and many of the successful alumni of the Department have not returned for graduate work. But most of them recognize the need of graduate studies and return to the Department after an interval of a year or several years.

The principal lines of specialization, preferably chosen late in the undergraduate years, are:

(1) Economic Geology. Dealing with the origin and manner of occurrence of ores and nonmetallic industrial minerals, with an optional opportunity for courses in mining methods, mine valuation, and mineral eco-

(*Continued on page 220*)

Sketch map of Meteor Crater and the surrounding "devastated" area, Winslow, Arizona; compiled from maps of the United States Geological Survey and the published works of D. M. Barringer, George P. Merrill and Clyde Fisher. The meteor was a body of stone and iron, and its energy was due wholly to its mass and speed; it had no chemically explosive quality such as the atomic bomb possessed. Pound for pound the atomic bomb had many times the energy of the astronomic bomb.

The crater is 4150 feet in diameter from rim to rim, and is 570 feet deep; but during the many thousands of years since it struck the earth, much sand has been washed into it; the pit was originally at least 1000 feet deep. The explosion tore out nearly 800 million cubic yards of solid rock — limestone and sandstone — shattered them to bits, even pulverized them and melted some of the sandstone into glass. Indian tribes must have seen the entire show, for flint javelin-points are found under the rubble; but the long years have left not even a legend of the disaster. The dotted areas show where fragments of the meteor have been collected.

The Joukowski Airfoil

By DONALD THOMSEN
Department of Mathematics

ONE of the more theoretical methods used in the study of certain scientific and engineering problems is that of Conformal Mapping. It is a mathematical technique which has been highly specialized by the pure mathematician and yet one which at the same time has been used by applied mathematicians for many physical problems especially in the fields of electricity and hydrodynamics. It is a problem in the latter field which is of interest at the moment. Before specifically stating the problem, it seems best to outline briefly the mathematical theory behind conformal mapping as it stems from the complex variable calculus.

We are going to deal with functions of the type $w=f(z)$ where $w=u+iv$, $z=x+iy$ and $i^2=-1$. Suppose that the function $f(z)$ is analytic, *i.e.* has a derivative in a region D of the z-plane except possibly at certain points. By this function there is set up a correspondence between particular points in the z-plane and particular points in the w-plane. Such a process as this is called a mapping. It maps certain points in the z-plane into certain points in the w-plane.

At every point where $w=f(z)$ is analytic and $\frac{dw}{dz}\neq 0$, the mapping is conformal — *i.e.* two curves in the z-plane which intersect at an angle θ go into two curves

Fig. 1 *Staff drawing*

in the w-plane which intersect at an angle θ. Thus the transformation $w=z^2$ is conformal at all points of the z-plane except at the point $z=0$, for at that point $\frac{dw}{dz}=0$. It is rather easy to justify this statement as will be seen presently.

The transformation $w=z^2$ may be written in the polar exponential form where $w=Re^{i\phi}$ and $z=re^{i\theta}$. Thus it follows $Re^{i\phi}=r^2e^{2i\theta}$. R must equal r^2 and $\phi=2\theta$. Therefore a line through the origin in the z-plane goes into a line through the origin in the w-plane, making twice the angle with the horizontal axis (see Figure 1).

Consider a little more closely the transformation $w=z^2$ and see how it behaves for other values of z. The function $w=z^2$ can be written in the form $u+iv=(x^2-y^2)+i(2xy)$. For $u=$ constant there exist rectangular hyperbolas in the z-plane symmetric with the axes. For $v=$constant there appear again rectangular hyperbolas rotated through 45° and intersecting the first set at right angles. This illustrates the conformal property of the transformation in that orthogonal curves in one plane go into orthogonal curves in the other plane. Upon calculation it can be shown that for $x=$constant and $y=$constant there are two sets of orthogonal parabolas in the w-plane. These are the ideas and methods to be used in connection with a particular transformation which arises in aerodynamics

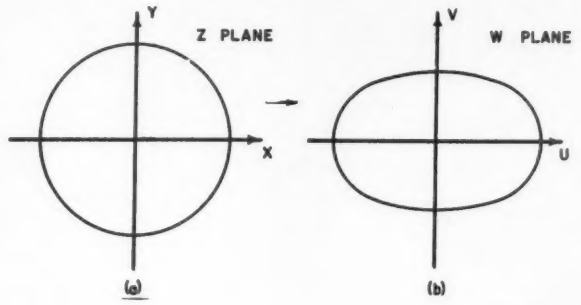


Fig. 2 *Staff drawing*

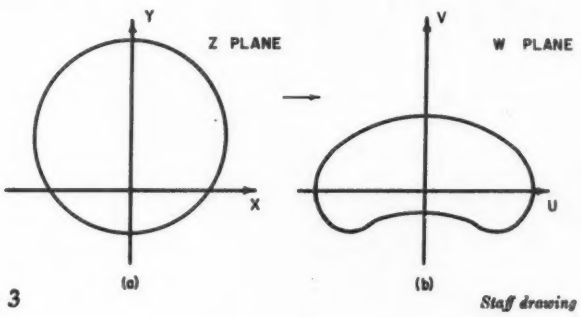


Fig. 3 *Staff drawing*

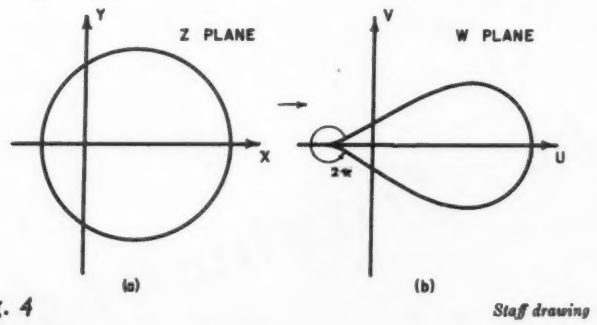


Fig. 4 *Staff drawing*

— namely, the Joukowski transformation and its extension.

The Joukowski transformation in its extended form

$$\frac{w-nc}{w+nc}=\left(\frac{z-c}{z+c}\right)^n$$

is important in the problem of mapping an aeroplane-wing profile on a circle. By an airfoil a cylinder is intended whose cross section is of the type in Figure 5b. In order to carry out this transformation there is to be presented later a rather ingenious method developed by Professor Richard H. Smith of the Aeronautical Engi-

neering Department at M. I. T. First, however, the special case of $n=2$ is going to be considered.

The transformation becomes then

$$w=z+\frac{c^2}{z}.$$

Suppose one assumes certain positions of a circle in the z-plane and notes the curves in the w-plane (see Figures 2, 3, 4). A combination of Figure 3 and Figure 4 produces the well-known Joukowski airfoil (see Figures 5a and 5b). For structural reasons the cusp on the end of the Joukowski airfoil is not desirable, and that is why one is led to investigate the more generalized form of the transformation,

$$\frac{w-nc}{w+nc}=\left(\frac{z-c}{z+c}\right)^n.$$

Thus the added parameter n may be used. By varying n ever so little from 2 close approximations to standard airfoils can be obtained.

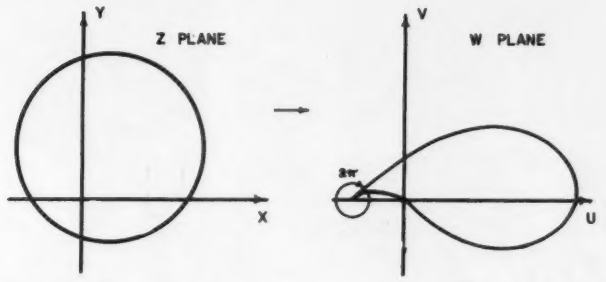


Fig. 5 *Staff drawing*

If n is taken equal to 1.94 and the center of the circle at $\frac{x_0}{c}=.063$ and $\frac{y_0}{c}=.08$, an airfoil is found which looks very much like a Clark Y. If the lift is known on the cylinder, the streamlines can be calculated and then by the same transformation one can designate the streamlines about the airfoil. It must be supposed in this connection that the flow is incompressible, and irrotational. A similar process can be carried out to find the pressure distribution over the airfoil by use of a pressure transformation.

The mechanics of carrying out the transformation

$$\frac{w-nc}{w+nc}=\left(\frac{z-c}{z+c}\right)^n \qquad n=1.94$$

is quite a problem. Professor Smith has used in his courses the following straightforward method. An analysis of the transformation from the point of view of bipolar coördinates is very helpful. Let $z-c=r_1e^{i\theta_1}$,

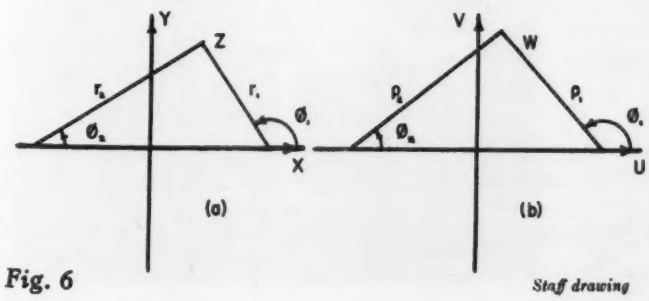


Fig. 6 *Staff drawing*

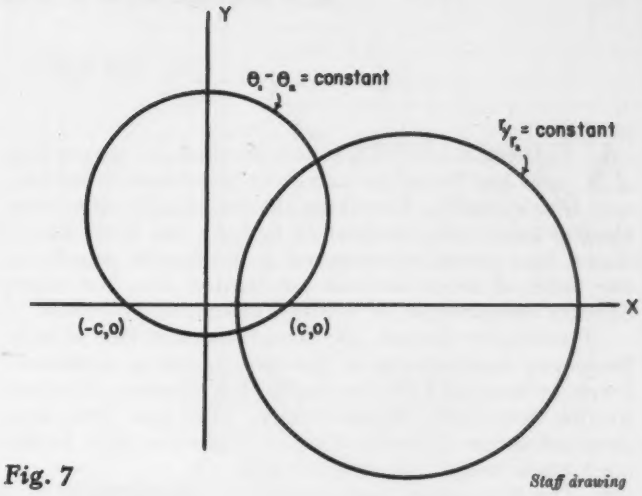


Fig. 7 *Staff drawing*

$z+c=r_2e^{i\theta_2}$, $w-nc=\rho_1e^{i\phi_1}$, and $w+nc=\rho_2e^{i\phi_2}$. Compare with Figure 6. The transformation now takes on the form

$$\frac{\rho_1e^{i\phi_1}}{\rho_2e^{i\phi_2}}=\left(\frac{r_1e^{i\theta_1}}{r_2e^{i\theta_2}}\right)^n \qquad \text{or}$$

$$\frac{\rho_1}{\rho_2}e^{i(\phi_1-\phi_2)}=\left(\frac{r_1}{r_2}\right)^n e^{in(\theta_1-\theta_2)}$$

Thus $\frac{\rho_1}{\rho_2}=\left(\frac{r_1}{r_2}\right)^n$ and $\phi_1-\phi_2=n(\theta_1+\theta_2)$.

In the bipolar system $\frac{r_1}{r_2}=$constant and $\theta_1-\theta_2=$constant are the fundamental curves (orthogonal circles) of the coördinate system just as $x=$constant and $y=$constant are fundamental in the Cartesian system. See Figure 7. By simply changing the values of the constant in each case above different coördinate curves of the orthogonal system are obtained. Now suppose one has a large sheet of paper with the bipolar system carefully drawn on it. Draw in the circle to be transformed. The problem is to find the transform of a point A on this circle. Through this point passes one circle

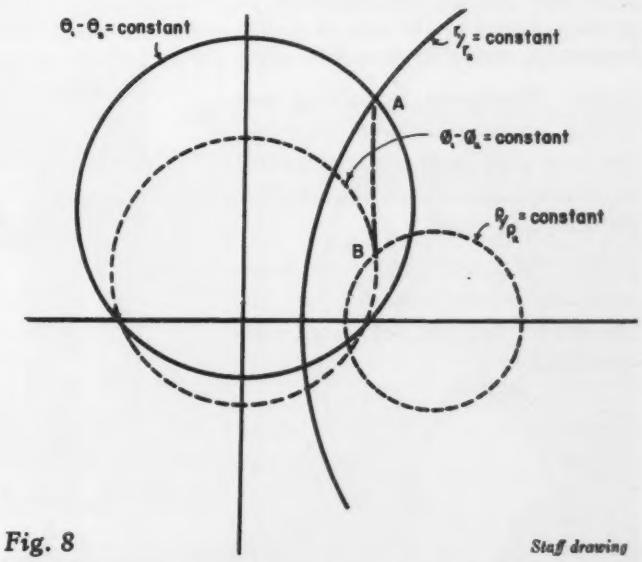


Fig. 8 *Staff drawing*

(*Continued on page 230*)

Dielectric Heating

By HENRY L. LEE, 2-47

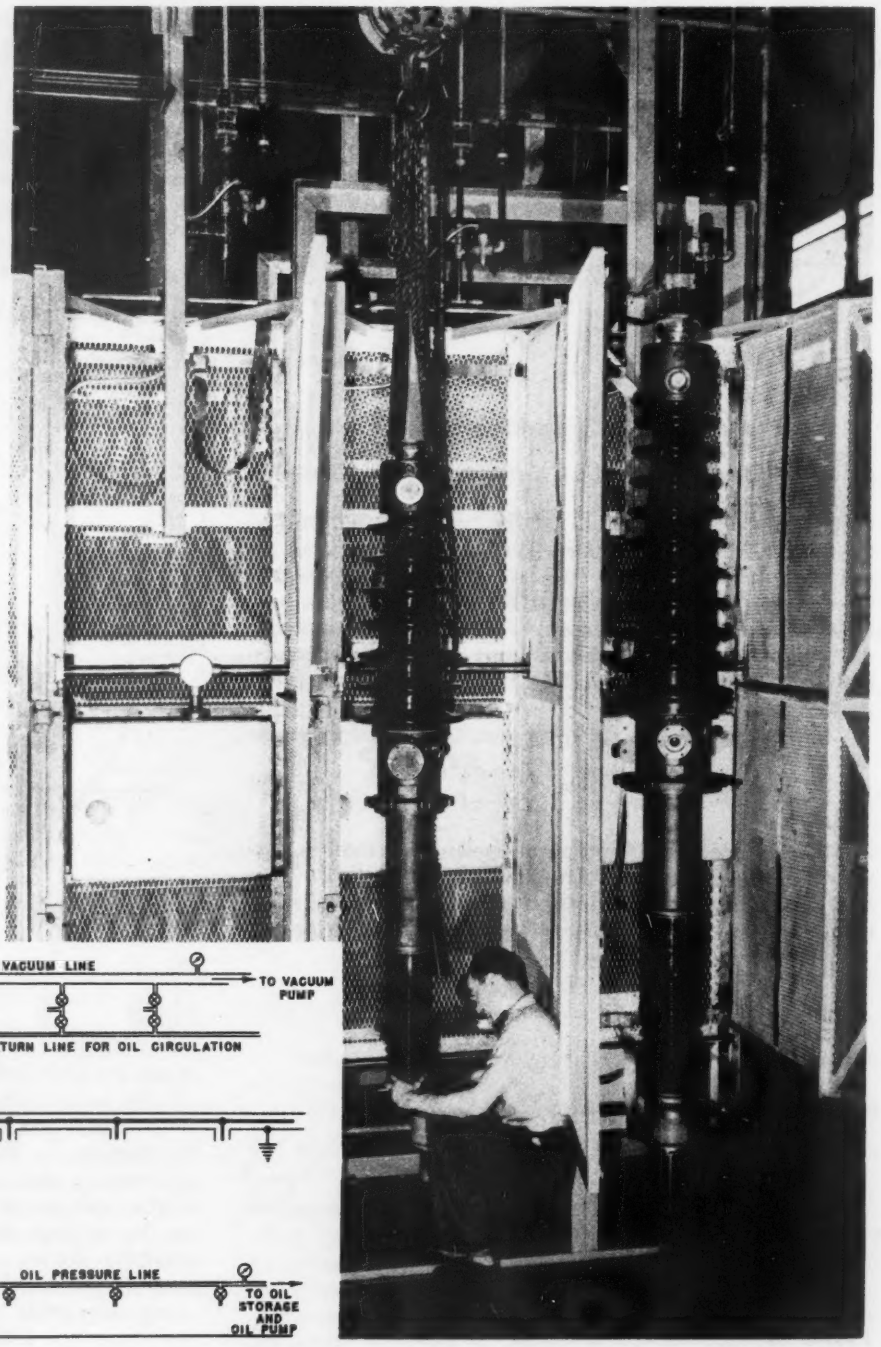
A COMPARATIVELY new method of generating heat has found its way from the research laboratory into industry. Involving the use of high frequency electric fields, this method of heating has been introduced into manufacturing and is finding its way from the fields of more obvious application into the more obscure complexities of modern industrial processes.

Previous to the war, the most important role of high frequency heating was in the therapeutic or artificial-fever devices used by the medical profession. Visitors at the New York World Fair in 1939 and 1940 saw demonstrations of such machines; electric light bulbs were made to light up when in mid-air. The high initial cost was what prevented the immediate application of high frequency equipment to various fields of manufacturing.

During the war, cost became a minor consideration, and high frequency techniques were applied to industry. Also, the efficiency of the required equipment had been greatly increased and the costs of production of the equipment lowered. The results showed that the initial cost can be quickly made up in production increases and improved products when the equipment is carefully applied.

Government censorship regulations have limited the discussion of certain phases of the use of radio-frequency equipment. But production details are now becoming available, and it is our purpose to acquaint the reader with the fundamental theory, principal advantages and limitations, and fields of application of dielectric heating.

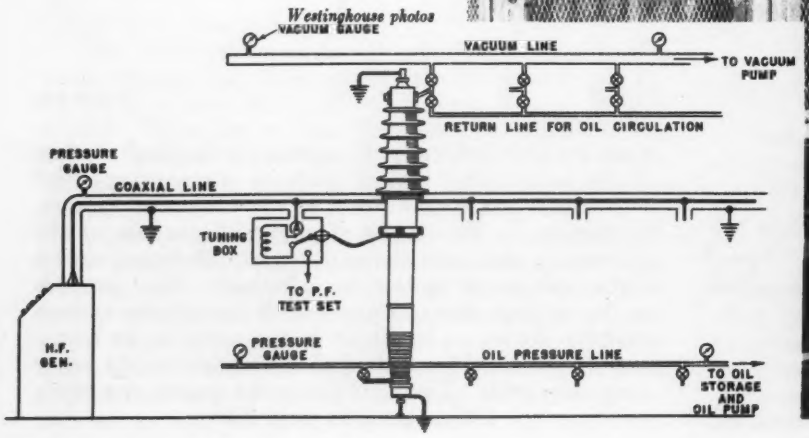
The two most important industrial uses of dielectric heating techniques, prior to the war, seem to be in the processes of cementing and drying. Electrostatic fields were used to heat the glue cementing the plural soles of shoes, lessening the danger of harming the leather because of the accuracy of temperature control that was possible. Tobacco was dried to the desired moisture content without removing the tobacco from the original



Right: Workman installing one of the large condenser bushings for heat and oil treatment. Heat drives out excess water and oil is forced in instead.

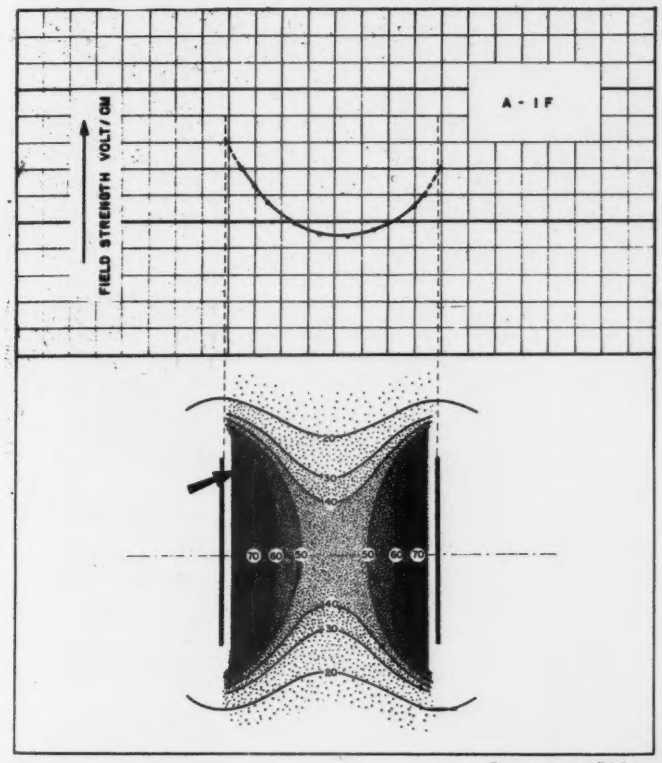
Below: Schematic diagram showing the main elements in the dielectric heating of condenser bushings.

Westinghouse photos



shipping barrels. High frequencies were ideal in that they gave a wide range of sensitivity of temperature control. Patents and patent applications of the prewar period covered the possibilities of cooking, pasteurizing milk, drying sponges, and the manufacture of laminated fibrous articles such as wood. Under the catalytic action of war, these uses were expanded and new applications became apparent, along with a number of intrinsic problems.

Dielectric or electric non-conducting materials are, in general, poor thermal conductors; and because of this inability to transfer heat, it is difficult to raise the volume-temperature of the substance without subjecting the outer surfaces to excessive temperature. In order to heat the center of a non-conductor, it usually has been necessary to establish a temperature gradient and then to wait while the heat penetrated. This is



Department of Biology

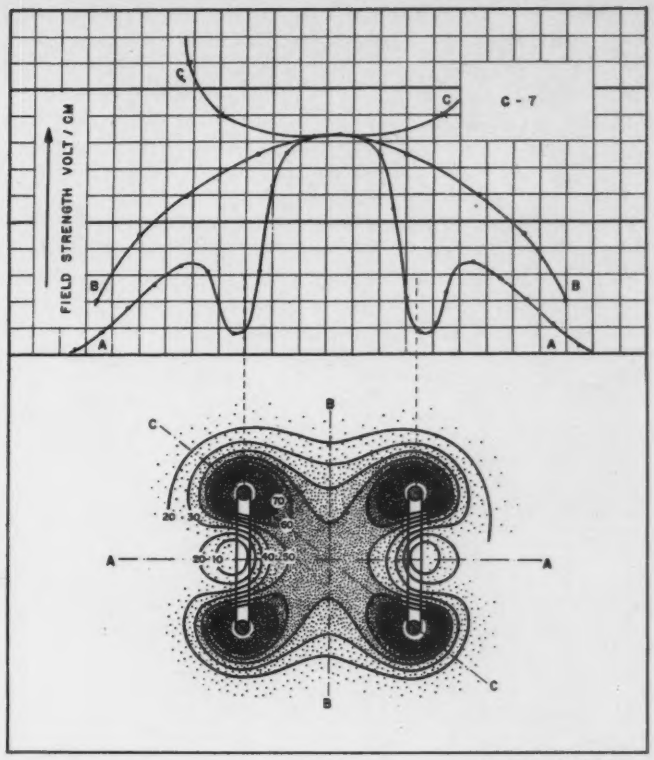
Field strength between flat electrodes

often unsuccessful as the external temperature necessary for a desired internal temperature is such as to burn or mar the outer surfaces. It is often imperative to reduce production time, and hours spent while the material reposes in large ovens must be avoided.

When using dielectric methods, the heat is not transferred, but is actually generated at the exact place that the heat is desired, right in the very center of a non-conductor. The heat may be said to be the dielectric loss produced when the material is subjected to an alternating electric field of radio-frequencies. The alternating field imposes an increased agitation on the molecules of the material, and increases its internal energy and temperature. This power loss is approximately measured by

$$P = 2\pi f E^2 C \cos\phi$$

where P equals the power in watts, f the frequency in cycles per second, E the applied rms voltage, C the



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Using rings as electrodes focuses field at center along AA

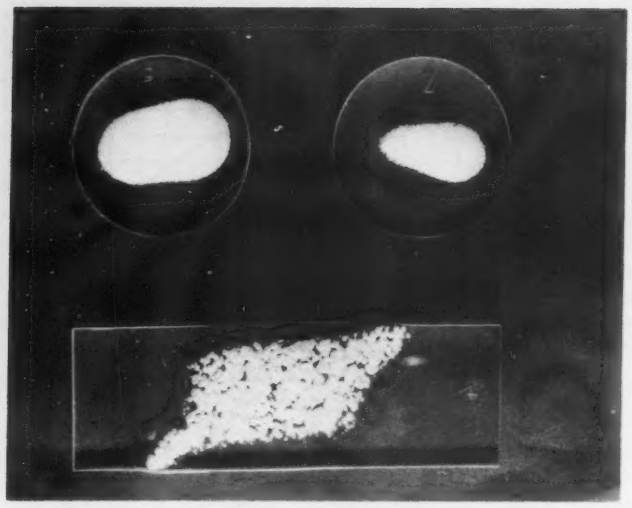
capacitance, and $\cos\phi$ the power factor. A more convenient expression may be written:

$$W = \frac{1.41 A f E^2 e'' \times 10^{-12}}{d}$$

where W equals the rate of heating in watts, A the area of the electrode in square inches, d the thickness of the material in inches, f the frequency in cycles per second,

Operating the controls for heating the condenser bushings

Westinghouse photo



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Pieces of lucite with their centers evaporated by concentration of high-frequency fields

E the rms voltage, and e'' the loss factor of the material, which is $e' \tan \phi$ where e' is the dielectric constant of the material.

There exist, however, certain limitations for any given load, beyond which the equations will not hold. In applying the principles of dielectric heating, the dimensions of the load are extremely important since they influence electrode design and the tuning of the electronic circuit supplying the alternating field. The thickness of the load should be uniform to insure uniform heating. With regards to area, the capacitive reactance of a large area may be such as to make tuning of the load extremely difficult if not impossible; on the other hand, the length of the load may be such as to create standing waves and to thus produce uneven heating. Considering electrical limitations, it is found that the maximum voltage is limited by the breakdown value of the air or of the dielectric, and by the cost of arc-over preventives. Frequency ranges are limited by the natural resonant frequency of the load, a function of its dimensions and physical constants. Materials such as pure polystyrene and quartz have power loss factors below 0.005 and as such are very hard to heat by dielectric methods. The practical lower limit of the loss factor lies between 0.005 and 0.01, while the upper limit of the loss factor blends into the range where the material becomes sufficiently conductive so as to respond to magnetic fields. Thus the problems facing the engineer are the designing of the generator and a satisfactory preparation of the load before introducing it to the field; for example, wedge-shaped articles may be laid in alternatingly reversed directions, giving a uniform element.

In considering electrode design, there are some interesting points which may be made. As previously mentioned, the dimensions and physical constants of the load play an important part in the circuit. On the other hand, the design of the electrodes or condenser plates can also give a wide range of results. Figure 1, showing two flat plates as electrodes, demonstrates the fact that the field is not uniform in intensity between the plates. If uniform heating is desired, something must be done to correct for this non-uniformity. One solution has been the use of rotating plates of various shapes that subject only a portion of the material at a time to the action of the field. Figure 2 shows the effect of using circular rings as electrodes. It will be noticed that the field strength is very small at the center of the rings but that the intensity farther along AA is subject to a very sharp increase. This ability to concentrate field strength by means of electrode design may also be seen from Figure 3, which shows three pieces of lucite that have had their centers evaporated by means of intensive h.f. heating. The outside surfaces have not been disturbed and their chemistry remains the same. A slight bulging is noticeable because

Making adjustments on the individual bushing cells

Westinghouse photo

of the pressure of the vaporized material, but the region of h.f. concentration is distinct. These illustrations were prepared by the M. I. T. Department of Biology, using the apparatus shown in Figure 4, for the purpose of studying therapeutic techniques and instrumentation, and for studying the effects of h.f. fields on organic material.

It should be noted that there is no appreciable heat generated in the electrodes. Any heating of the electrodes is usually caused by surface leakage from the load in cases of direct contact between the load and electrodes.

In reviewing the economic advantages, we find that the high frequency method of heat generation:

1. Produces a result not possible by other methods of heating. Concentration of heat or uniform volume-heating is more quickly accomplished and more easily controlled than by any other process.

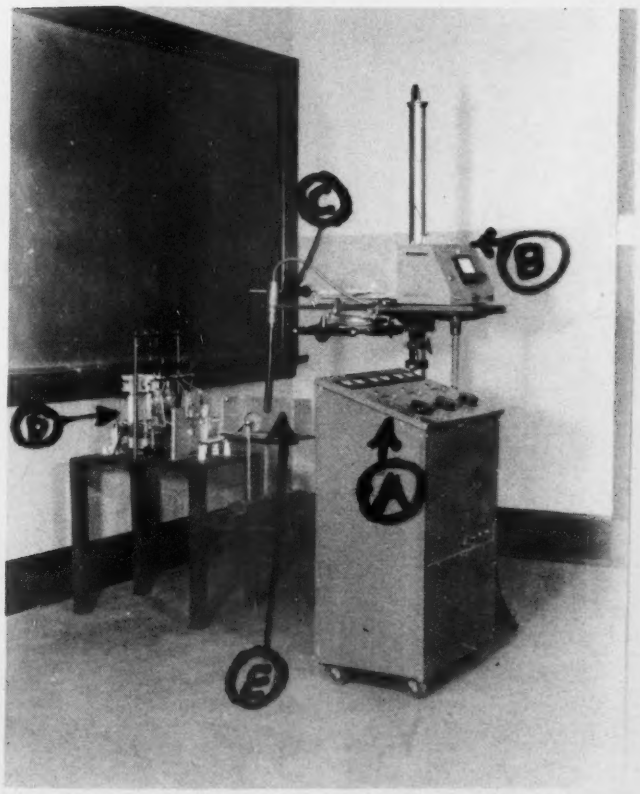
2. Increases speed of production. Production time may be greatly reduced. The heating is produced instantly and may be stopped abruptly. There is no time lost while waiting for equipment to cool.

High-frequency heating used in the moulding of plastic *Westinghouse photo*

Laboratory apparatus for direct measurement of field intensities

A. *Power pack controls*
B. *Field intensity meter*
C. *Probe for field intensity meter*
D. *Oscillator for generating high frequencies*
E. *Polystyrene box, filled with suitable dielectric liquids*

Department of Biology



3. Produces heating at the exact point that it is needed, reducing over-all power consumption. "Chimney" losses must no longer be added to power input.

4. Is clean and compact, advantages which speak quite strongly for themselves.

5. Requires no physical contact between the load and electrodes; but the electrodes may act as the faces of a press, if desired, and supply pressure as well as power to the load.

6. Improves quality of product because of uniformity of heating, and reduces surface damages because of the uniformity of temperature. No high external temperature is needed.

7. Is applicable to a wide range of operations and has found uses in many ways that were at first unsuspected.

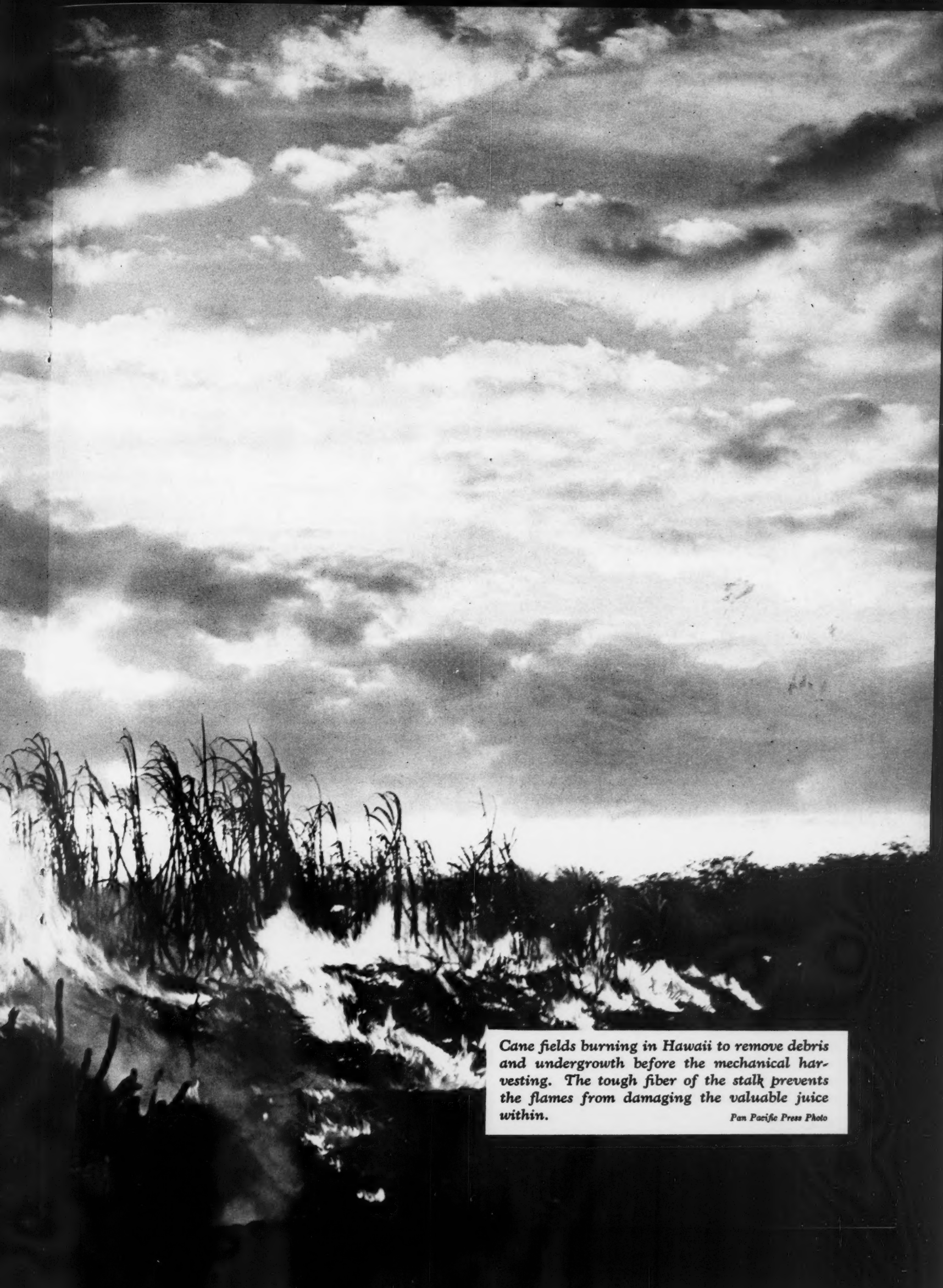
On the other hand, perhaps offsetting the decrease in actual power consumption, is the relatively high cost of electrical energy as compared with other sources. It has been estimated that, including direct operating cost and maintenance, the cost will be between two and a half and four cents per kw-hr.* This relatively higher cost must be weighed against the numerous advantages.

Prominent among the important applications of h.f. heating is its application as a drying agent, where it dries wood, sponges, penicillin, leather, tobacco, and thick organic chemicals requiring speed and uniformity of treatment. Some foods have been satisfactorily dehydrated with h.f. heat.

Another important application is the heating of glues. Shoe leather, plywood, sheets of wood, and other materials are quickly cemented under the action of pressure and hot glue. The electrodes serve as press faces. Sheets of wood can be joined together and impregnated with resinous compounds. These compounds seal the surface so effectively that the wood, which

* Carl J. Madsen, *Electrical World*, September 15, 1945.

(*Continued on page 230*)



Cane fields burning in Hawaii to remove debris and undergrowth before the mechanical harvesting. The tough fiber of the stalk prevents the flames from damaging the valuable juice within.

Pan Pacific Press Photo

THE TECH ENGINEERING NEWS

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Comes the Revolution

With this issue we'd like to call attention to the new TECH ENGINEERING NEWS promotions. You've seen these men's names on the masthead during the past year — now they'll appear in new positions which reflect our judgment of the fine work they've performed.

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This year's annual T.E.N. banquet, the twenty-seventh in our checkered history, laid waste to quite a bit of food and drink at the Statler a couple of weeks ago. The gag rule was rigidly enforced, and the only non-staff man we couldn't suppress was Mr. Henry B. Kane, chairman of the Institute's Advisory Council on Undergraduate Publications. Livening up the occasion was Editor-Elect Weil, who, after failing to make the General Manager disappear, confined himself to more conventional magic tricks.

Seriously, we're quite proud of the work accomplished by staff members this past year, and are taking this opportunity to bring to our readers' attention the fate of the more industrious.

THE MANAGING BOARD, Volume 27.

The Dragon's Den

And each, in his separate star . . .

The most vital problem facing the engineering student during college years is his choice of profession or field of specialization. The decision each individual makes at this time not only is of paramount importance in his own life but also is a contributing factor to the future development of our industrial and economic systems.

That a subject of such universal import and personal consequence receives so little attention here at the Institute reflects badly upon the entire educational program.

The choice of a high school graduate between the technical and scientific fields on one hand and the medical and liberal arts professions on the other is one that is made with relative ease and assurance. True, there are a very few fortunate persons whose interests and ability would fit them for work in either of these two divisions of training; but the choice of the great majority is practically defined by the aptitudes found in secondary school either for mathematics and the related science courses or for language and history.

But when the prospective engineering student receives, together with his application blanks for admission to Tech, a request that he make a tentative selection of his course of study, it is an unusual (or a very foolish) person who can make such a decision with any degree of confidence. The reason for this, obviously, is that the student has not the necessary knowledge and experience to decide at this point just which of the many fields open to him would be the most interesting. Knowing a lovely red-head in Manhattan might give him inspiration, but it won't help him decide whether to study gas-turbine design with the mechanical engineers or to make his million in Course XV.

This situation is intensified by the necessarily limited high school courses in biology, physics, and chemistry. Few such courses at present cover aeronautics or electronics, and a great many other important branches of applied science receive no attention at all.

Here at the Institute, sporadic and generally ineffectual attempts to remedy this situation have been made in the past in the form of departmental teas, lectures, and so forth, held for those freshmen who might be interested. These attempts were not particularly successful, chiefly because the majority of students had *not* been impressed with their responsibility to themselves and because a number of the departments were not especially interested in the proceedings.

In recent years, there has been even less attention given this problem. The influence of the war upon M. I. T. was to give to the many research programs carried on here such prominence that most students felt that the educational functions of the Institute had been relegated to a position of relative unimportance. Some departments, involved in this research work, became notably indifferent to student needs. The widespread reference to Tech as "The Factory" is indicative, in part, of the student reaction to this official indifference.

It is possible for a very determined and persistent person to make an intelligent choice of his future, despite the absence of any sort of guidance from the Institute and the lack of readily available information in the library or elsewhere. But the few students willing to make this effort are not those who need such help.

Now that we are no longer working under wartime stress, the Institute should turn its attention once more toward its primary purpose — that of training scientists and engineers. And in keeping with this, it should be emphasized to the entering student that his most important duty during the first year at Tech is to decide in which course of study he is the most interested. To assist him in this choice, a program such as that advocated by Professor Mead of the Geology Department might be instituted, in which a series of departmental tours, coördinated with discussion and essay work, actually be incorporated into the first term schedule of each entering class.

Even if only a few in every class were helped by such a program, it would have proved of value. A person working at a job which he really enjoys is not only happier but also more certain of success than one who chooses his profession because "it has a great future."

As students, we are investing in our future — let us each be certain that it will be a going concern.

S. L. S.

The Pillory

Know all ye readers that the following persons have been convicted of being on the staff of that magazine known as The Tech Engineering News, and for that rank offense they are hereby sentenced to a one month stand in the public pillory.

Sidney L. Smith, 2-47

Why our readers have been exposed each month to idiosyncratic ramblings on the editorial page cryptically signed S. L. S. is a mystery of long standing at the *T.E.N.* office. The man behind those initials entered the service of the Dragon as one of the thousands of freshmen clamoring to join the staff. By systematically blowing cigarette smoke in the eyes of various General Managers he finally reached the point where it was clear that he must either be kicked upstairs or fired. The Dragon was a glutton for punishment. Here Smith is.

Besides *T.E.N.* Sidney Layton Smith apportions his time between women, chemistry, women, and women. At present his concentration is in the last-named field after certain unfortunate events, started when he mistook the office for a chemical storehouse and began filling all the empty drawers with bottles of assorted noxious fluids.

In addition Smith is inspired by music and poetry — especially that of A. A. Milne. It is only too easy to walk unsuspectingly into the office and be suddenly confronted with Sid lecturing on the adventures of some species of snail! Another of Sid's outstanding qualities is his faithfulness; he's probably the most faithful gentleman on the staff — what with so many to be faithful to!

One would hardly suspect that a boyhood environment of Honolulu and the old South — explaining Sid's southern accent and predilection for tropical moonlit nights — would lead to Chemical Engineering as a profession. But, nevertheless, armed with a notebook of simplifying assumptions, Smith has managed to acquire one of the highest ratings in his course.

With an easy smile and a well-practiced "persecuted look" Sid quietly manages to have his way in most everything. As the guiding spirit behind the unearthing of the Dragon and the fatherly overseer of the staff hirelings, he has become well respected and liked by the people who work with him. The future holds bright prospects for *T.E.N.*'s ever cheerful Casanova and lighthearted Simon Legree.

Richard A. Cleveland, 2-47

It is July of 1944. A tall, fair-haired boy steps off the train at South Station and stares wide-eyed at the brand new world presented to him in the form of Boston, Mass. It is none other than our hero, Richard A. Cleveland, fresh out of Upper Darby High, and eager to start shaping his career as a Mechanical Engineer. He is immediately pounced upon by a number of fraternity men who have thirstily been looking for just such a naive little fellow. They spirit him away, wine him, dine him; and before long a slightly dazed but completely befuddled Cleveland has become a pledge at Phi Kappa.

Richard attacks M. I. T. without hesitation, throwing himself bodily into the great sea of equations and formulas that comprise Tech, whereupon he is immediately and unceremoniously tossed back. Obviously, Upper Darby High has been a source of disillusionment as regards his intellectual prowess. But Dick is undaunted, and his freshman year sees him struggling with the problems posed both by Tech and by the pledge period and initiation at Phi Kappa. He mutters, of course, and complains, but fights on courageously.

The first year passes. Things have become easier. This does not mean that Dick is used to the ways of Tech, for he is a slow fellow. Rather, finding them unalterable, he has come to accept them passively. Also, he is now fraternity man, which gives him great joy.

The sophomore year passes somewhat uneventfully, with Richard spending his time studying three-hinged arches and women, and acquiring a bit of that savoir faire which is so necessary in the proper social circles. Richard intends to travel only in the proper social circles — poor disillusioned boy!

Somewhere along the way Dick gets entangled in a publication — our own *T.E.N.* Thrashing about for something to do, Richard tries his hand at the literary department. But Kent S. Putnam, the E.C.M.A. critic, rebukes his efforts with the question "Who is Richard Cleveland?" Completely crushed by this overwhelming blow, Dick recoils onto the business staff, just in time to find the manager's position vacant. By a process of elimination — he is the only man left without a job — Dick gets the post. He has been vainly "buggering the books" ever since.

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The American Telephone and Telegraph Company, through advice and assistance, coordinates all Bell System activities.

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Briefing the News . . .

Our Universities at War . .

In the 1946 January-February issue of the *Army Ordnance* magazine appears an article "Our Universities at War" by Karl T. Compton, president of M. I. T. In this article Dr. Compton demonstrates, by describing war research work done at Tech and at other colleges throughout the country, the contributions the educational institutions made toward winning the war.

The most important work of the universities was, according to Dr. Compton, "in the initial conception, reductions to practice, and often initial production for military use of many of our most effective new devices."

The point is emphasized that the Government saved a great deal of money, as well as the lives of many men, by its investment in research work. For instance, only a few days after a microwave early-warning radar set had been installed near the southern tip of England, it was used to guide back a formation of heavy bombers which had lost their way. The value it saved in planes and equipment alone far exceeded the total of the MEW program.

As a measure of the value of the contributions of the universities, Dr. Compton wrote, "I venture the statement that our educational institutions rank with our manufacturing industry and transportation system as the principal supporting lines of military power in time of war and of reserve strength in time of peace."

X-Ray Strain Studies . . .

A new method of determining the distribution of strains in metals by means of X-ray diffraction has been developed. In operation an X-ray picture is made of a small section of the metal which is about 1/500 of an inch thick and well polished on both sides. The planes of atoms within the metallic crystal-structure diffract the rays at various angles so that they do not hit the X-ray film, leaving a white space on it. However, the atomic planes which are distorted due to strains diffract the rays at different angles so that some of them do hit the paper, causing dark spots on it. Exposures are made of the metal at a series of angles, and it is tilted through a number of degrees so that the spots disappear. By plotting a graph, showing the change in the percentage of area covered by spots in each of the pictures, the distribution of strain can be discovered. Strains may also be introduced in the specimen while it is being examined. This method is expected to prove useful in studying the effects of annealing and the way in which strains are formed.

XP-81, Turbo-Driven Propeller . . .

The debut of the Consolidated Vultee XP-81, first plane ever to fly with a gas turbine designed for propeller drive, has been announced. The first flight of this experimental plane was recently made by the Army Air Forces. The success of the plane is a step toward the swift propulsion of huge civilian aerial transports in the near future.

Powered by a combination of the new Propjet (propeller-drive gas turbine) in the nose and an I-40 jet engine between cockpit and tail, the XP-81 is the most powerful fighter in the world. The light and slender Propjet and the I-40 jet engine together can produce nearly as much power as all four reciprocating engines on a B-29 Superfortress and can drive the small, bullet-like fighter more than 500 miles an hour.

This tremendous and easily controlled power gives the compact XP-81 a number of flight advantages, including maximum performance from treetop level to substratosphere, sustained high speed, superb maneuverability, long range, sharp angle of climb, quick take-off, and a minimum of vibration.

On take-offs of the XP-81, both the Propjet and the I-40 jet engine are used. Both of them are started in a matter of seconds. Neither requires a warm-up. With both propeller and jet thrust being used, the plane takes off quickly and climbs at a steep angle.

For cruising, only the Propjet power plant is used. The Propjet performs best and most economically while maintaining high speed for sustained periods. This gives the XP-81 long range for a fighter. The I-40 jet performs with maximum efficiency at high altitudes.

Besides propelling this versa-

(*Continued on page 230*)

CONVENIENCE AND LUXURY

IN BUDD'S NEW SLEEPING CAR EQUIPMENT

The day of the open berth is passing. Sleeping cars of the future, designed by Budd, will have private rooms—unexampled in convenience and luxury. Budd has designed four new types of sleeping car accommodations of which one is:

THE CABIN

This is a spacious individual room with complete appointments for day and night traveling. It has its own toilet, lavatory and wardrobe—and individual control of air-conditioning. The bed is pre-made. The seat is very wide and comfortable.

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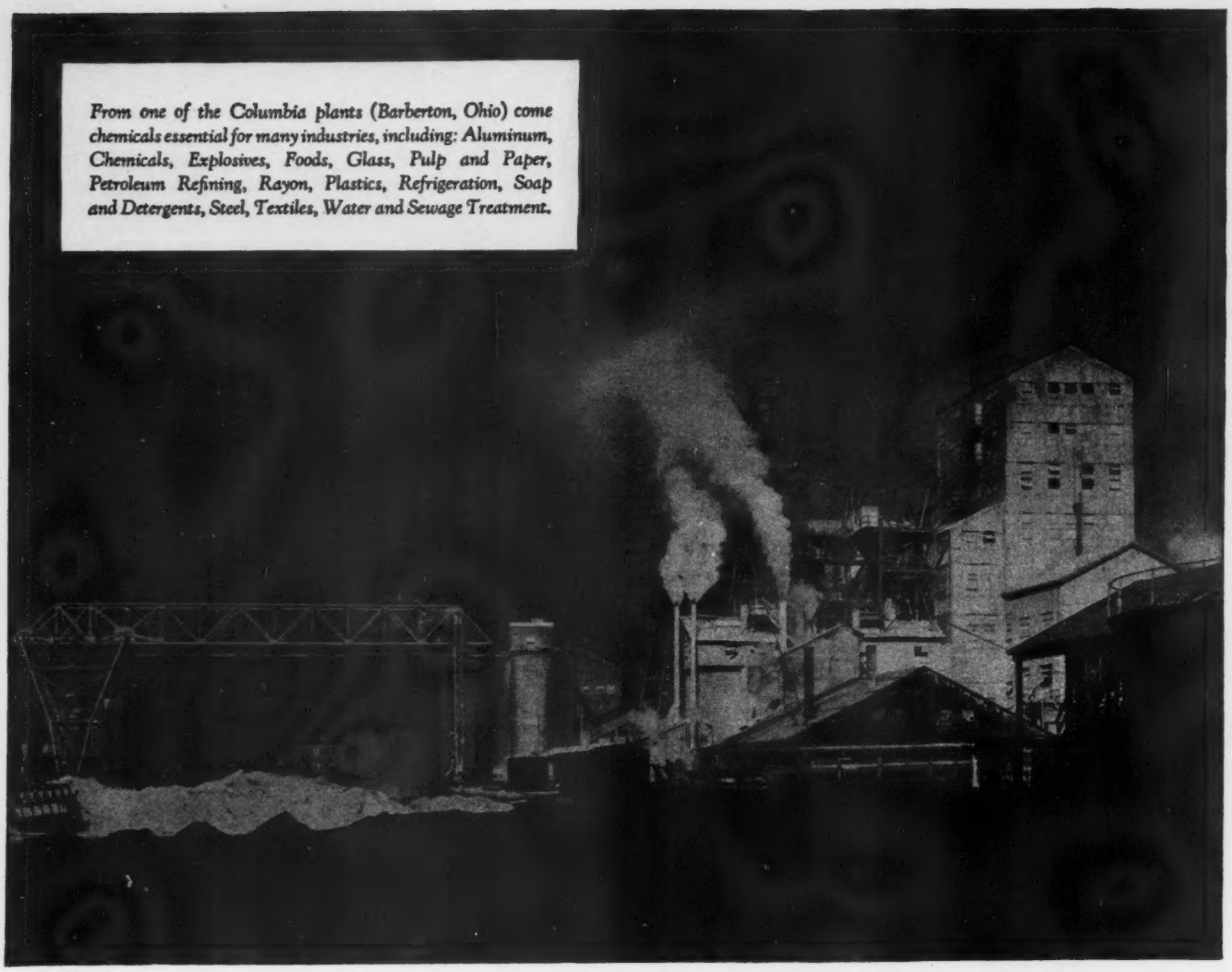
EDWARD G. BUDD MANUFACTURING COMPANY — Budd



From one of the Columbia plants (Barberton, Ohio) come chemicals essential for many industries, including: Aluminum, Chemicals, Explosives, Foods, Glass, Pulp and Paper, Petroleum Refining, Rayon, Plastics, Refrigeration, Soap and Detergents, Steel, Textiles, Water and Sewage Treatment.

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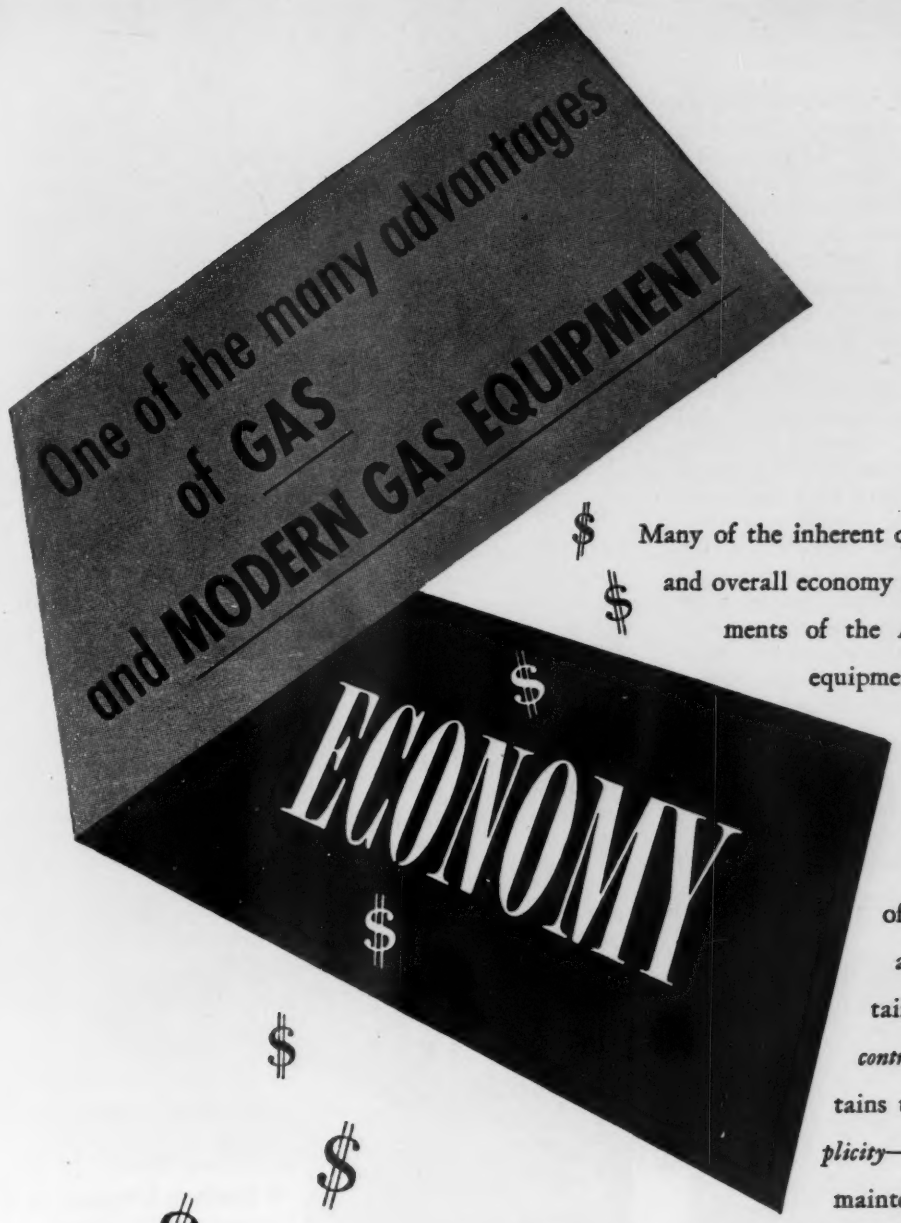

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THIS IS M.I.T. — GEOLOGY

(*Continued from page 203*)

nomics. Mineralogy and physical chemistry are important among the undergraduate courses. Graduate research work has the advantage of the Department's excellent spectrographic laboratory. This line of specialization leads to service with mining companies in exploration and mine development and employment by government agencies in economic geological work. Many of the alumni in this field have achieved positions of outstanding importance. The present directors of the geological surveys of Mexico and Venezuela were trained at M. I. T.

(2) Petroleum Geology. In the undergraduate years, stratigraphy, paleontology, sedimentation, and structural geology are emphasized, followed by more specialized geology dealing with petroleum and natural gas. Graduate research work may vary with the interests and desires of the individual. At the present time, research is in progress on the relations of radioactivity to the genesis of petroleum, involving precise measurements of the various types of radiation emitted by radioactive materials and their effects on the organic constituents of the source rocks of petroleum. Men trained in this field find interesting employment in the petroleum industry in exploration for oil and gas and in connection with its production.

(3) Engineering Geology. A broad general training in geology is followed with courses giving attention to the application of geology to engineering problems. A course in soils mechanics in the Civil Engineering Department is desirable as part of the undergraduate work.

Lava flow at Davis Lake, Oregon — *Technology Review*

This line of study leads to employment by governmental agencies or industrial companies engaged in the building of large-scale engineering structures such as dams and reservoirs, bridges, tunnels, highways, and landing fields. He may find work in problems involving underground water and water supply, stream control, or shoreline engineering.

(4) Geology and Geophysics. Designed to train men in both of these branches of science and consequently requiring considerable emphasis on physics and electrical engineering in addition to geology. The application of geophysical methods to the discovery of

(*Continued on page 228*)

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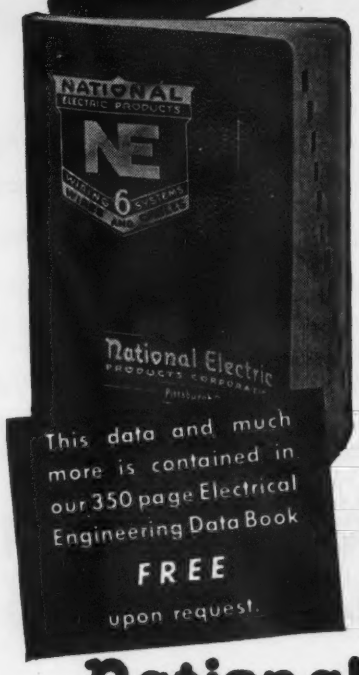

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The doctor • • • in shirt sleeves

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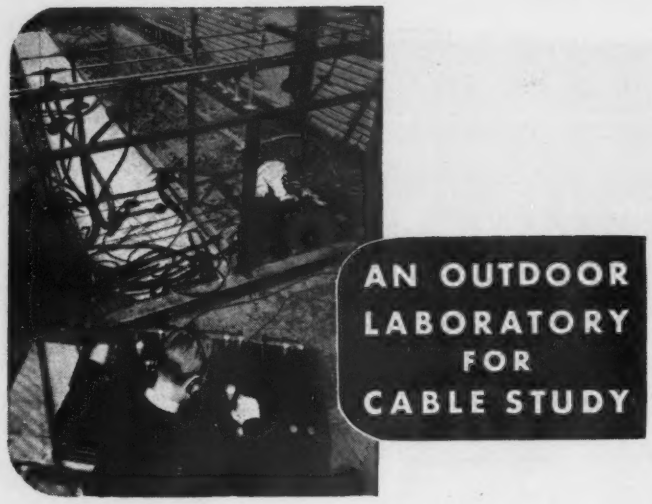

Nothing is guessed at, nothing is taken for granted by the engineers in charge of Okonite's cable proving ground. Buried in various types of chemically different and highly corrosive earth, pulled into conduit or installed overhead, electrical cables are tested under controlled conditions of temperature, voltage and loading conditions duplicating those of actual operation.

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BROWN & SHARPE
TOOLS

SUPERSONICS

(*Continued from page 198*)

quickly become cloudy at the surface of separation, and this gradually spreads until the emulsion is complete. In making photographic emulsions, the use of supersonics prevents the agglomeration of the particles which lowers the resolving power of the film. Supersonic vibrations are also able to split up large organic molecules. By using high frequencies starch molecules have been split into five or six parts, and cane sugar has been reduced into monosaccharides.

Strangely enough, these supersonic vibrations have almost the opposite effect on fine suspensions of liquids or solids in a gas, such as dust, mist, or smoke. Here supersonics cause the particles to coagulate rapidly into larger particles, and this method could be used to remove most of the solid matter from the smoke of factories.

There are also biological effects from these waves. Under powerful supersonic excitation, protozoa, and small animals such as frogs and small fish are killed. The cell membranes are torn to pieces, and the red blood corpuscles are destroyed. These biological effects may lead to the production of an effective death-ray, if supersonics of sufficient intensity are ever developed, but it is to be hoped that the resources of science will be put to a more useful end.

SUGAR RESEARCH

(*Continued from page 197*)

are or may be used in the plastics industry have been taken up by Dr. Louis Long of the Sugar Research Foundation at M. I. T. in a booklet entitled "Sugar and Sugar By-Products in the Plastics Industries."

Reactions that block certain groups of the sugar molecule are among the most fundamental reactions of all sugar chemistry. It may be seen that the problem of getting plastics and useful chemicals from sugar is also related to the study of fundamental reactions of the sugars. Many of these reactions have been inadequately studied, or have not been studied since more modern methods have been available. The Sugar Research Foundation at M. I. T. therefore does considerable work in the development of fundamental sugar chemistry. Studies on the reaction of various sugars and derivatives with aldehydes, ketones, mercaptans, alcohols and acids have been made. The oxidation of sugar derivatives by lead tetraacetate has been extensively investigated at M. I. T. with the result that new methods of synthesis of sugar derivatives have been devised. Of course, it will take years of steady work before fundamental research in sugars produces useful results.

The Sugar Research Foundation has adequate funds available to purchase equipment, and its laboratories are as well equipped as possible considering the difficulties in obtaining equipment these days. Seniors and graduate students in courses V and X are permitted to do research for their theses, using this equipment and supplies belonging to the Foundation. Graduate students may apply for part-time and full-time assistantships with the Foundation. A course in the chemistry of carbohydrates (5.562) is given whenever the demand is sufficient. Visitors to the Foundation's laboratories (Room 6-327 and vicinity) are always welcome — and none of the work is secret!

One reason why television is coming fast . . .

YOU are looking at two bell-shaped cathode ray bulbs mass-produced by Corning during the war for military radar. In most ways they are like the bulbs Corning is now preparing to make for a television set that may end up in your living room.

And that's why television is nearer than you think! Years ago television in its infancy was the "father" of radar. Today, as a result of development to meet war's urgent needs, radar can more properly be called the parent of tomorrow's television. These bulbs are just one example of how glass developed by Corning for use in war will have an equally important place in peacetime living. The list is long. It includes special "metalized" glass parts for wartime radio and radar equipment. A method of mass-producing high-quality optical glass for the Army and Navy. Glass pipelines and glass pumps that are impervious to chemical attack and outlive other materials. Glass so resistant to thermal shock it can be heated cherry-red and then sprayed with ice water without breaking. All these and many more research achievements establish glass made by Corning as versatile engineering material with ever increasing possibilities. That's why it will pay you to learn all you can about glass now. And remember, too, Corning is an outfit that knows glass. Corning Glass Works, Corning, New York.

CORNING
means
Research in Glass

Air

MASS PRECISION AND

The tolerances to which Nichols works in metal are so fine that they are easily affected by the invisible forces of the air surrounding them. A few degrees of temperature change could cause dimensional differences disastrous to the interchangeability required in "mass precision" parts and assemblies.

This is why Nichols maintains a *Gage Laboratory* plus *Test* and *Assembly Rooms* that are completely equipped and air-conditioned. In them, standards of temperature and cleanliness are constantly controlled with scientific vigilance. Also, in the Nichols *shop*, every effort is made to guard precision. Every micrometer and gage is checked against masters in the Gage Laboratory by schedule. New, certified, gage-blocks are received every 90 days. Thus Nichols maintains a direct contact with the Bureau of Standards.

When you require the mass production of parts and assemblies to tolerances so accurate that they are affected by air — you need Nichols. Send for your copy of "Mass Precision" today.

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A full-color reproduction of this painting suitable for framing will be sent upon request

"No unhitching... no feeding!"

So claimed Charles Duryea for his horseless carriage. He had built it in a barn in Springfield, Massachusetts, and it was the first of its kind in the country.

It was the year 1892, when gasoline was to be bought by day at the hardware store and by night at the corner drug store. The new contraption had "two speeds forward and one reverse, and was operated by an up and down movement of the steering handle."

We have come a long distance since Charles Duryea's day. One measure of that distance is the universal use in motor vehicles of ball and roller bearings such as SKF produces. For SKF has contributed much to the automotive industry, and the presence of SKF Bearings is a warranty of quiet performance and low maintenance cost.

Since SKF makes many types of anti-friction bearings, an SKF engineer can give you expert help in selecting

THE RIGHT BEARING FOR THE RIGHT PLACE

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BALL AND ROLLER BEARINGS

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THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY
offers the following Professional Courses:

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The duration of each of the above undergraduate Courses is four academic years, with the exception of Architecture, Food Technology (Five Year Course), Physical Biology, and the co-operative Courses in Electrical Engineering and in Mechanical Engineering, which extend over a period of five years, and City Planning Practice which covers a period of six years. In addition to the Bachelor's degree, the above five and six year Courses, with the exception of Architecture, lead also to the Master's degree.

Graduate study, leading to the Master's and Doctor's degrees, is offered in Ceramics and in most of the above professional Courses.

A five year Course is offered which combines study in Engineering or Science, and Economics. This leads to the degree of Bachelor of Science in the professional field, and to the degree of Master of Science in Economics and Engineering or Economics and Natural Science.

For information about admission, communicate with the Director of Admissions.

The Catalogue for the academic year will be sent free on request.

IT'S LIFE FOR BEVERAGES *and death to fire*

To a raging fire, Carbon Dioxide gas means sudden, certain death. Yet this same gas puts "life" in beverages—tongue-tingling bubbles that make soft drinks sparkle. For fighting men it's a life saver in other ways . . . inflating collapsible life-rafts and "Mae West" life-jackets; creating synthetic "smoke screens"; shielding packaged foods against spoilage; processing blood plasma and penicillin.

In its varied applications, Pureco Carbon Dioxide reflects the far-ranging usefulness of all Air Reduction products . . . from oxygen tents to welding torches.

For interesting and educational reading, write Dept. CP for your free copy of the 56-page illustrated book "A Quarter Century of Progress". It describes and illustrates the operations and products of Air Reduction and its subsidiaries.

The operating subsidiaries of Air Reduction Company, Inc., are:

AIR REDUCTION SALES COMPANY
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THE OHIO CHEMICAL & MFG. CO.
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•

WILSON WELDER & METALS CO., INC.
Arc Welding Equipment

•

AIRCO EXPORT CORPORATION
International Sales Representative of these Companies

AIRCO

AIR REDUCTION
60 East 42nd Street, New York 17, N. Y.

Try this FLEXIBLE SHAFT Quiz

To paraphrase a popular old ditty—another little quiz won't do you any harm. So, take a few minutes and test your knowledge of flexible shafts. Below are some basic questions. Cover up the answers and see what you can do with them.

WHAT ARE FLEXIBLE SHAFTS?	Flexible shafts are basic mechanical elements designed and made for transmitting rotational power around turns and in other cases where a solid shaft can't be used. They are built up practically solid of layers of strong wire, wound in a way that produces strength with flexibility.
ARE ALL FLEXIBLE SHAFTS ALIKE?	Far from it. They come in two classes — 1. for Power Drives — 2. for Remote Controls. Construction of the two classes is similar, but shafts differ in flexibility, torsional strength, torsional deflection and other characteristics to meet the requirements of their respective fields.
HOW BIG DO FLEXIBLE SHAFTS COME?	Power drive shafts come in diameters from .045" to .750". Remote control shafts from .130" to .437"
WHAT ADVANTAGES DO FLEXIBLE SHAFTS OFFER?	Flexible shafts reduce to a *single* element the number of parts required to transmit power or remote control between practically any two points. This eliminates gearing and simplifies manufacturing and lowers costs. Also, flexible shafts make possible better designs because they permit connected members to be placed wherever desirable to save space and to facilitate assembly, operation and servicing.
ARE FLEXIBLE SHAFTS RELIABLE?	For many years S. S. White flexible shafts, to the extent of millions of feet annually, have been serving in a wide variety of applications in aircraft, automobiles, radios, machine and portable tools, and a long list of other products. This is the best proof of their reliability.

AS AN ENGINEER you'll find it helpful to be familiar with flexible shafts and their possibilities. BULLETIN 4501 will give you basic facts and technical data. A free copy is yours for the asking. Please mention your college and course when you write.

S.S.WHITE INDUSTRIAL DIVISION
THE S. S. WHITE DENTAL MFG. CO.
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FLEXIBLE SHAFTS • FLEXIBLE SHAFT TOOLS • AIRCRAFT ACCESSORIES
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THIS IS M.I.T. — GEOLOGY

(*Continued from page 220*)

petroleum and ores and to the solving of noneconomic geological problems is of great and growing importance. There is a constant demand for people trained in this field by oil companies, mining companies, and governmental agencies.

(5) Mineralogy and X-Ray Crystallography. A minor emphasis is placed on geology and major emphasis on theoretical mineralogy and X-ray crystallography. The Department has a well-equipped laboratory for X-ray crystallography including several important installations which have been developed by departmental staff and are not available elsewhere. The rapidly growing importance of X-ray crystallography in many fields of industry has created a growing demand for people trained in this field for work in industry and industrial research.

(6) General Geology. Designed for people not primarily concerned with industrial employment and looking forward to work with state or federal geological surveys or an academic career in teaching and research.

A phase of usefulness presented by geology which can well be emphasized is its general cultural value. The world we live in and travel over becomes more interesting, and the joy of life is notably enhanced by understanding the meaning of the landscape, the streams, the rocks, the shoreline features of lakes and the sea. It is a misfortune that we do not have a generally available introductory course in geology early in the curriculum at M. I. T., not only for its broad cultural value, but to provide an awareness of the existence of this interesting and important branch of science which, in contrast to biology, physics, and chemistry, is almost universally absent from the curricula of preparatory and high schools.

Watch for the
MARCH ISSUE
OF
T. E. N.
Out Soon!

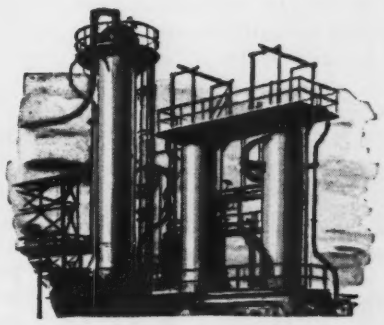
HOW MUCH DO YOU KNOW

About a metal you see every day?

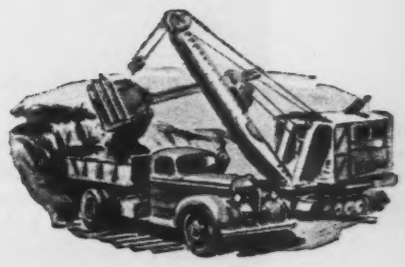
WHAT MAKES STAINLESS STEEL "STAINLESS"?

This high-speed train wears a gleaming sheath of steel that's stainless—stainless because of the CHROMIUM it contains. Trains, planes, buses and cars of the future all will be finer still—and lighter, stronger, safer—because of increasing use of chromium in their steels.

WHY DOES HER KITCHEN COME *"jiffy clean"*?—Sparkling pans, pressure cooker, tableware, shining sink and working surfaces in this modern kitchen all are highly resistant to rust, stain, corrosion—are easy to clean, attractive and long-lasting. Why? Because CHROMIUM has imparted these prized qualities to the steels of which they are made.



HOW DO REFINERIES STAND THE *"acid test"*?—Highly corrosive acids help refine America's oceans of high octane gasoline. But today's refineries withstand fierce acids, high temperatures and pressures—because CHROMIUM stoutly fortifies their metals.



WHY CAN THIS TRUCK *"take it"*?—The steels of many truck and automobile bodies, springs, gears and other parts contain CHROMIUM—for chromium helps give these steels amazing resistance to shock, fatigue, wear.

CHROMIUM is well known to many people for the powerful influence it exerts upon steel. Most of the alloy steels relied upon today for beauty, durability, and resistance to heat and corrosion now contain this interesting element.

Many years ago Units of Union Carbide discovered how to extract chromium from its native ore. They since have been constantly at work on the ever growing list of chromium alloys and their uses.

Union Carbide does not make or fabricate steel. ELECTRO METALLURGICAL COMPANY and other Units of UCC, however, supply to industry such wonder-working metals as chromium, manganese, and vanadium. With these, and the many other basic raw materials produced by UCC, industry improves a thousand and one products that serve all of us.

▼

FREE: "PRODUCTS AND PROCESSES OF UCC," *Booklet P-2, tells an illustrated story of many basic materials industry uses to build this world about us. Send for a copy.*

UNION CARBIDE AND CARBON CORPORATION

30 East 42nd Street UCC **New York 17, N. Y.**

Principal Units in the United States and their Products

ALLOYS AND METALS—Electro Metallurgical Company, Haynes Stellite Company, Kemet Laboratories Company, Inc., United States Vanadium Corporation
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INDUSTRIAL GASES AND CARBIDE—The Linde Air Products Company, The Oxweld Railroad Service Company, The Prest-O-Lite Company, Inc.

THE JOUKOWSKI AIRFOIL

(*Continued from page 205*)

of the form $\frac{r_1}{r_2}$ = constant and one circle of the form $\theta_1 - \theta_2$ = constant. Suppose $\frac{r_1}{r_2} = .75$ and $\theta_1 - \theta_2 = 80°$. Calculate $(.75)^{1.94}$ and $1.94 \times 80°$ by the transformation as revised above, thus obtaining the coördinates of the transformed point $\frac{\rho_1}{\rho_2} = .5$ and $\phi_1 - \phi_2 = 155.2°$. Look for the circle $\frac{\rho_1}{\rho_2} = .5$ and $\phi_1 - \phi_2 = 155.2°$ on the chart of the bipolar system and the appropriate intersection will be the transformed point. Actually one can superimpose the w-plane on the z-plane by simply supposing that $nc = 1.94c$ has been scaled down to the same length as c and thus do all the work from one chart of the bipolar system. In other words, one can let the two poles in the z-plane coincide with the two poles in the w-plane. A rough sketch of the transformation of a typical point A into a point B is given in Figure 8.

Thus by the use of the bipolar system of coördinates it has been shown how to handle the rather complicated Joukowski transformation in its extended form. This is really the second part of a no less important problem — namely the determination of the transformation itself. In many problems the transformations are determined, and then nothing more is done in the way of actual calculations. In this article a demonstration has been given as to how to handle a rather difficult transformation and really carry it out by a straightforward method.

With the aid of the Smith charts the flow patterns and pressure distributions of various airfoil shapes may be semi-graphically determined. The research aerodynamicist is thus able to predict approximately the performance of airfoils. However, compressibility and rotational effects which were considered negligible in our transformations increase in importance as the speed of aircraft approaches the supersonic region and our predictions must become increasingly less reliable.

Previous to the hi-speed air era into which war development has brought us, the actual Joukowski transformation which results in airfoils with cusp trailing edges was not of immediate importance. The effects of compressibility at hi-speed, however, have dictated the cusp trailing edge and the aeronautical structural engineers have succeeded in designing such "hi-speed wings" which have enabled aircraft to fly at speeds that were not believed possible a few short years ago.

DIELECTRIC HEATING

(*Continued from page 209*)

now possesses a high natural polish, resists heat, mild acids, and water. The wood may be immersed in water. True, it sinks to the bottom of the container because of the weight added by the resin, but it does not absorb any moisture, and may be removed and dried as easily as a piece of chinaware. Tables constructed of such wood resist the detrimental effects of hot dishes and such. Bonded plywood has been used in providing weatherproof radar antenna coverings for sea-going vessels.

H.f. sewing is important. Overlapping pieces of material may be pressed together by two wheels, serving also as electrodes, and cemented by vulcanization.

In grain elevators, where weevils and other insects may destroy large amounts of grain, treatment with h.f. kills the weevils but does not harm the grain. The dielectric constant of the weevil is greater than that of the grain and the insect is killed long before any heating takes place in the grain.

Textiles, relying upon friction between fibers for their strength, may be strengthened by baking the twist into the fiber with h.f.

Experiments have been conducted to test the application of dielectric heating to cooking. Some satisfactory results have been obtained; bread cooked with h.f. tends to brown inside instead of on the crust. Toasting bread is rather unsuccessful in that the bread is uniformly dehydrated and becomes merely dried-bread. Hard-boiled eggs and frankfurters have been cooked with success. Quantitative tests will be conducted to determine the exact effect of high frequencies on food.

What the future brings in the field of dielectric heating remains to the diligence of the scientist and the engineer.

BRIEFING THE NEWS . . .

(*Continued from page 216*)

tile fighter at great speed on long flights, the Propjet also pressurizes the cabin. Air blows from the axial flow compressor of the Propjet to do this job. At high altitudes, the engine heats the air that flows into the cabin.

The XP-81 has a wing span of 50 feet 6 inches, and a fuselage length of 40 feet 8 inches. It weighs 22,000 pounds, including both engines. Knifelike edges on the low-slung wings and the torpedo-shaped nose reduce drag.

The propeller-drive gas turbine fits flush in the tapering nose of the XP-81. Air flows into a duct around the rim of the nose of the plane and into the axial flow compressor, which is directly behind the reduction gears on the Propjet. The compressed air is sucked into combustion chambers. There the burning of the fuel raises the temperature and velocity of the air and gases, which then, with great energy, exert pressure on the buckets of the turbine wheel. The turbine, spinning at more than 10,000 r.p.m., at a temperature over 1,500 degrees Fahrenheit, absorbs the major part of the energy in the gases.

The turbine powers the compressor and through reduction gears drives the propeller. The energy remaining in the gases passes through the turbine and discharging rearward releases a reactive forward jet thrust. The jet exhaust on the Propjet slants down and out of the fuselage, almost below the cabin.

The I-40 functions in principle much like the Propjet, except that the turbine only turns a centrifugal compressor. The remaining power of the blazing-hot air and gases passes on out a large exhaust through the tail, releasing the forward reactive force which at maximum reaches 4,200 pounds of thrust.

Both the Propjet and the I-40 burn the same fuel, usually kerosene. The Propjet is more economical in fuel consumption than the I-40, which is one of the factors in the long range attainable by the XP-81, when cruising swiftly on the propeller-driven gas turbine alone.

Radio relay towers, about 50 miles apart, will gradually replace thousands of miles of telegraph poles and wires.

Now, telegrams "leapfrog" storms through RCA Radio Relay

With the radio relay system, developed by RCA, Western Union will be able to send telegraph messages between principal cities without poles and wires.

"Wires down due to storm" will no longer disrupt communications. For this new system can transmit telegrams and radiophotos by invisible electric microwaves. These beams span distances up to fifty miles between towers and are completely unaffected by even the angriest storms.

When large numbers of communications circuits are required, these automatic radio relay systems are more efficient than the pole and wire system . . . are less costly to build and maintain. They'll be particularly useful, too, in areas such as China and South America where distances are great and long-line services have not been developed.

This revolutionary stride in communications was made possible by research in RCA Laboratories—the same "make it better" research that goes into *all* RCA products.

And when you buy an RCA Victor radio or television set or a Victrola* radiophonograph, you enjoy a unique pride of ownership. For you know, if it's an RCA it is one of the finest instruments of its kind that science has achieved.

Radio Corporation of America, RCA Building, Radio City, New York 20, N. Y. . . . Listen to The RCA Victor Show, Sundays, 4:30 P. M., Eastern Time, over the NBC Network.

Research in microwaves and electron tubes at RCA Laboratories led to the development by the RCA Victor Division of this automatic radio relay system. Here is a close-up view of a microwave reflector. This system holds great promise of linking television stations into networks, as well as relaying other forms of electric communications.

RCA **RADIO CORPORATION of AMERICA**

*Victrola, T. M. Reg. U. S. Pat. Off.

Start of a big whittling job

LOOK at this great, great grandpappy of the modern transport plane.

Most of it was virtually whittled out of wood.

Now, picture in its place a giant airliner of today with its huge wings, its growling engines, and its magnificent equipment. It, too, is a "whittling" job . . . by fabulous men.

Men who have no limits to their dreams. Men who have incredible skill with tools. Men who perform miracles with metals.

And it is a "whittling" job by *the hardest metal made by man* — an amazing new metal for cutting and forming other metals. Its name is Carboloy Cemented Carbide.

What gives our planes the endurance to fly thousands of *safe* miles in all weather in all climates? What helped to bring back warplanes with tail surfaces half shot away . . . with wings and engines mutilated by steel slugs?

The answer is *super-tough metal alloys.*

Engine parts, wing spars, armor plate and hundreds of other vital airplane parts literally have to be whittled out of these tough, hard alloys. This could never be done quickly and economically unless a harder metal like Carboloy were used for the cutting tools and forming dies.

In fact, high American Air Forces officers have said,

"We couldn't have produced our present aircraft engines on a production basis without carbide tools."

The reasons why Carboloy Cemented Carbide is used throughout the aviation industry and in hundreds of others are simply these:

1. **Its amazing ability to cut and form the toughest alloys at speeds that commonly triple the output of both men and machines.**
2. **Its unbelievable resistance to wear.**

In the air age to come, Carboloy will help bring many new benefits to everyone . . . consumers and manufacturers alike.

Its usefulness will multiply over and over again, not only in tools and dies in every phase of metal working, but also in wear-resistant parts in hundreds of products from automobiles to knife-sharpeners.

A challenge to industry!

It's 10 to 1 that our research men and field engineers can find applications for Carboloy in your plant that will help you improve quality and cut production costs. Why not accept this challenge?

Carboloy Company, Inc., Detroit 32, Mich.

CARBOLOY
(TRADE MARK) • CEMENTED CARBIDE

The Hardest Metal Made by Man

You just THINK you're touching aluminum, mister!

Pick it up . . . in your bare hands . . . anything made of aluminum. Your cigarette box. A saucepan. The foil on a chocolate bar.

You're not touching aluminum. You *never* have, never will.

The reason is very simple. Aluminum is constantly covered with the thinnest of thin "skins". It is Aluminum Oxide. You can scrape it off, but it re-forms immediately. In a split second.

This—the scientists at Alcoa's Aluminum Research Laboratories learned many years ago . . . but they didn't stop there. They wanted to know what could be done to this "skin" . . . how it could be made thicker, thinner, harder, porous . . . so that Aluminum products could be more useful and serviceable.

Out of this Alcoa research on the "skin" of aluminum have come many new things. Aluminum pistons of porous "skin", to hold oil. Aluminum trays of lush lustre that won't tarnish—ever. *Colored* aluminum—the color dyed right into the "skin".

Yes, Alcoa has found many ways of not only controlling this "skin" but also of making aluminum better and more versatile in many, many ways . . . *but the search still goes on* and always will.

This *search* calls to young men of science and engineering . . . and spells new opportunity to salesminded men of tomorrow.

The next time you pick up . . . in your bare hands . . . anything made of aluminum, say to yourself, "What *new* could I make this light, strong, durable metal do for man . . . some day?"

ALUMINUM COMPANY OF AMERICA, Gulf Building, Pittsburgh 19, Pennsylvania.

ALCOA FIRST IN **ALUMINUM**

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GE CAMPUS NEWS

RESEARCH AND ENGINEERING KEEP GENERAL ELECTRIC YEARS AHEAD

"ON TEST" AT GENERAL ELECTRIC

EACH year General Electric selects graduates of engineering colleges and assigns them to the Testing Department. For a period of 12 to 15 months they transfer from section to section, obtaining broad experience with a variety of apparatus, broad training in classroom and factory—to equip them for research, development, application, and manufacturing in the engineering field of their choice.

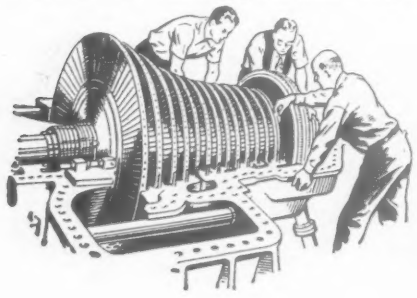
In formal parlance these men are members of the Student Engineering Course, but to them they are "on Test." And when they have graduated to join a large alumni body, they will speak of the days when they were Test men.

The Test man is constantly coached and advised in every way possible. He gains his first experience in assisting others in Testing equipment. As he assumes more responsibility, he may be placed in charge of testing a piece of apparatus with newer Test men as his assistants—or be selected to take charge of a complete line of equipment.

THE CLASSROOM COURSES

The General Course, open to all Test men, consists of a Business Section and four Engineering Sections: Electrical, Mechanical, Electronics, and Engineering Fundamentals.

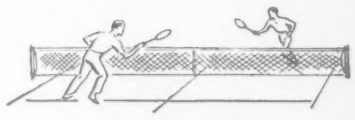
Sales Engineering is a special three-year program of practical experience and classwork. The men who take this course are selected from Test; and when they complete the program, their opportunities are in application engineering, general office sales, and in various Districts of the Company.



Another special program—for men with desirable qualifications—is design engineering. This program consists of Advanced Engineering and Creative Engineering, highly theoretical courses for a selected group of men. The Mechanical Design course helps to develop qualities of ingenuity and originality.

WELL-ROUNDED PROGRAM

Far from feeling lost in an impersonal company, the Test men have always been encouraged to join clubs that promote dances, hikes, tennis matches, golf, swimming, and other forms of recreation, as well as engineering societies in towns in which they work.



Many men who now hold key positions at General Electric and other companies started on G-E Test. And the Test courses are only part of the Company's educational program—the Business Training Course, for example, is another program to prepare employees for better opportunities.

General Electric Company, Schenectady, New York.

GENERAL ELECTRIC